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MARCH-APRIL 1960

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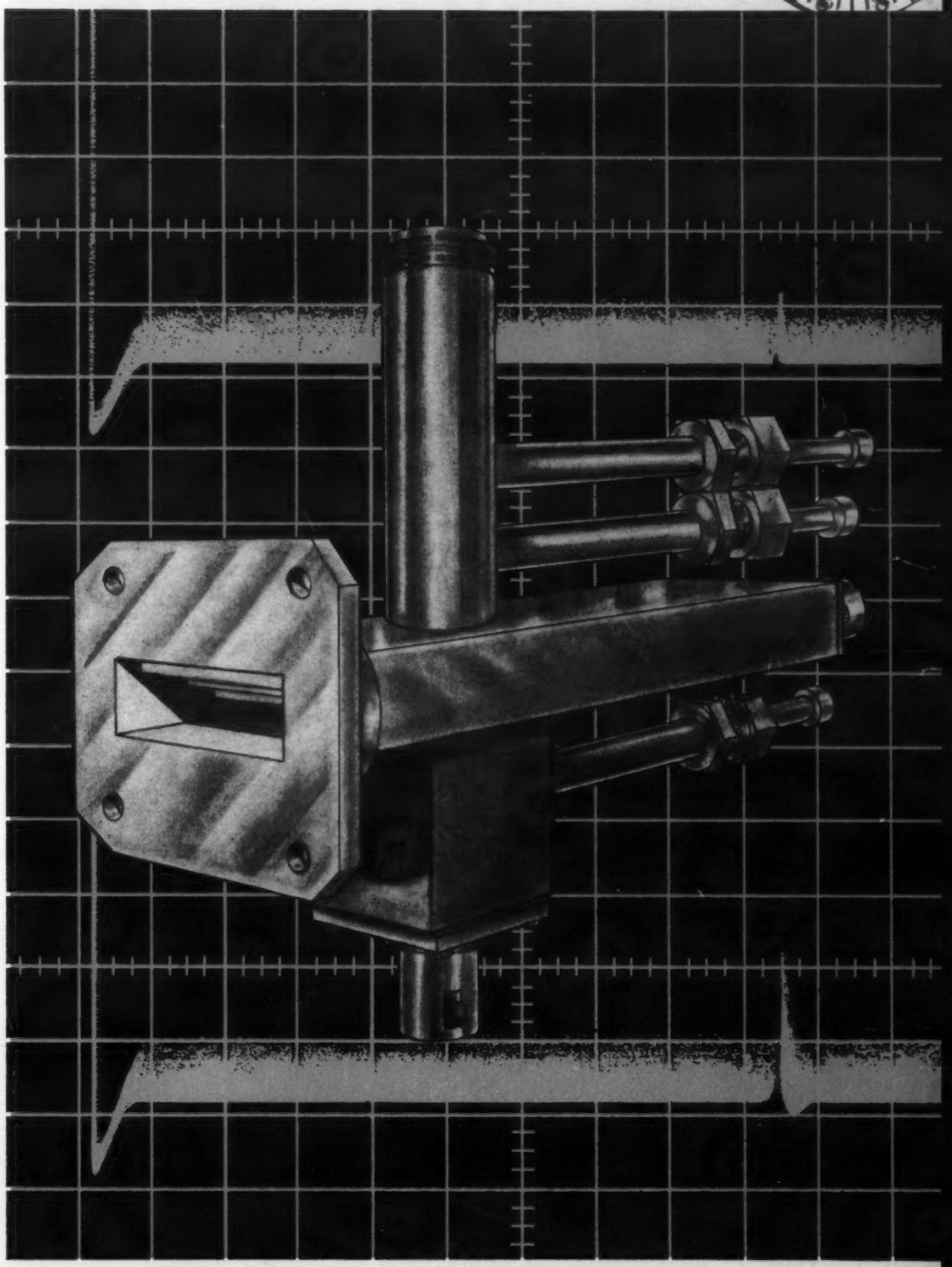
Timing Control Systems

Low Noise Amplifiers

Index to 1959



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Published bimonthly by Instruments Publishing Company Inc., 845 Ridge Ave., Pittsburgh 12, Pa. Printed at 1600 N. Main St., Pontiac, Ill. Accepted as Controlled Circulation Publication at Pontiac, Illinois.

BPA

Richard Rimbach, Publisher

Claude O. Morrison, Editor
(Commander U.S. Naval Reserve)

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Main Office: 845 Ridge Ave, Pgh 12, Pa., Fairfax 1-0161

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MSD MILITARY SYSTEMS DESIGN

VOLUME 4, NUMBER 2
MARCH-APRIL 1960

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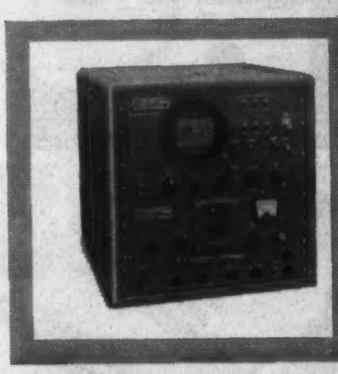

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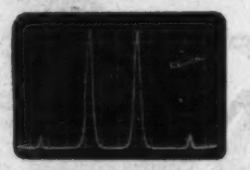
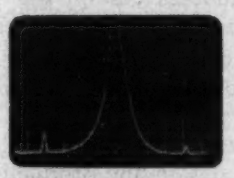


TWO TONE TEST*
Fixed sweep width 2000 cps. Full scale log sideband tones 1.5 kc and 2.1 kc from carrier (not shown). Odd order I. M. distortion products down 37 db.



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MSD editorial

Space Probe Keynotes IRE

"BROADENING HORIZONS" was an appropriate keynote for the IRE International Convention, March 21-24, at the New York Coliseum. As the most newsworthy development to illustrate the theme of the convention, the data signal from Pioneer V space probe, headlined as the most distant man-contrived message ever received, was used to open the convention.

Examples of Broadening Horizons were emphasized by technical papers and exhibits in the fields of Noise Reduction, Frequency Control, Temperature and Radiation Tolerance, Space/Weight Reduction, Reliability and Maintainability, in Antenna Design and Systems Engineering.

Low-noise amplifiers, particularly masers and parametric amplifiers, have shown marked improvement and refinements within the past year, and are being combined with traveling wave tube techniques for new broadband effectiveness. Noise as a factor of amplifier design ceases to be a problem in most applications, as background thermal temperatures are usually higher than the noise contribution of the preamplifier stages now available. Statistical methods of data treatment to separate coherent signals from an overlay of ambient noise were also reported. Testing techniques for elimination of noisy and defective resistors were also shown, and the Air Force proposed a new Radio Interference Standard for communications equipment.

World-wide horizons in system frequency control are now available which depend on the use of VLF (very low frequency) radio transmission from stations which are controlled by atomic clock methods. Signals from such VLF transmissions are less subject to ionospheric frequency shift than the WWV transmissions previously used for frequency stabilization.

Without question the most sensational component development of the past year is the Esaki or Tunnel Diode. Although not primarily a low-noise device, its noise factor is low enough to impose no penalty in most applications. Its freedom from radiation effects, small size, low power requirements, and most favorable of all, its anticipated low cost, has generated much design activity as evidenced by the number of exhibits, papers and commercial offerings in this field. Although tunnel diodes are less than a year old and still in the developmental stage, application research is being actively pushed by many experimenters.

High temperature horizons are notably being ex-

THE COVER

Two A-scope displays illustrate the approximately 6-db signal-to-noise improvement achieved by using the S-band parametric amplifier also shown. Scope pictures and amplifier sketch are by courtesy of the Apparatus Division, Texas Instruments Incorporated. Article on page 26.

tended by the TIMM (Thermionic Integrated Micromodule) technique of using heat evolved by electron activity within the tube, rather than to attempt to dissipate it. This method reduces the tube space almost to the vanishing point, and incorporates resistances and capacitors with the tube into an integrated circuit module which vies with transistors for space/weight savings. Temperature above 600°C are tolerated by the TIMM, which is also radiation resistant.

Improvements in reliability appear to be as much in the re-thinking of principles and refining of terms as in new techniques. Statistical methods of reliability control and improved testing methods were also in evidence. A continued interest in maintainability techniques as adapted to modular and micromodular military equipment conformations was also emphasized by many speakers and exhibits.

Antenna design news emphasized electronic scanning systems as meeting the demands of high-speed scanning with high-gain beams. Problems arising from satellite and space-craft communications, another reminder of broadening horizons, were also discussed. A statistical computer method for rapidly determining the presence or absence of radar-echoes, thus increasing the effectiveness of early warning radar, was an important announcement in radar design.

A very lively and growing facet of the show is the emphasis on bio-medical electronics. Papers announced the discovery of new non-thermal effects of microwave radiation on living tissue, methods of physiological telemetry, detection of high-frequency and audio signals from body tissues, and the successful use of implantable electronic cardiac pacemakers in laboratory animals.

Military emphasis and end-use accounted for a majority of all developments; as usual however, process and industrial applications also showed considerable gains, particularly application of the statistical techniques via digital and analog computers. In this field, there is evidence that a wider understanding of statistical techniques can be credited with as much improvement in the state of the art as can be claimed by mechanical and electronic improvements in memories, circuitry and programming. This is to be expected, and the chief technical improvements in computer design are seen in improved speed/space/power/weight factors made possible by new solid-state materials, memory devices and circuits.

Engineering Short Courses

The Pennsylvania State University, University Park, Pa., will offer ten short courses from June 5 to September 30 covering Electrical Contacts, Machinability, Design Engineering, Electrical Precipitation, Underwater Missile Engineering, Atomic Shelter I and II, R&D Management Development, Work Measurement and Technical Report Writing. For detailed announcements write, Engineering Seminars, Conference Center, The Pennsylvania State University, University Park, Pa.

A special course on Modulation Theory and Systems, for practicing communications engineers, not for academic credit, will be offered by the Massachusetts Institute of Technology, from August 1 to 12, 1960. For details write Professor Elie J. Baghdady, Dept. of E. E., M. I. T., Cambridge, Mass.

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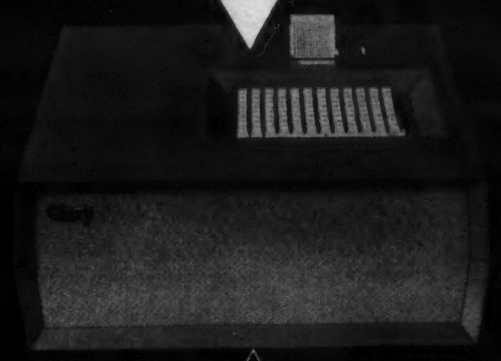

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CIRCLE 4 ON READER-SERVICE CARD

Digital Read-Out Oscilloscope Simplifies Measurements

FIG. 1. **RAPID ACCURACY** in measurement by non-technical production workers is possible with new Du Mont "425" Oscilloscope. If desired, digital output can also automatically actuate card punch or recorder.

A revolutionary high-speed oscilloscope which can rightfully lay claim to being the first in a "new generation" of these basic instruments has been announced by the Allen B. DuMont Laboratories, Inc. of Clifton, N. J. Product of a three-year development effort by the originators of the cathode ray oscilloscope, the unique features of this new 'scope of particular interest to systems designers are outlined in the accompanying article.

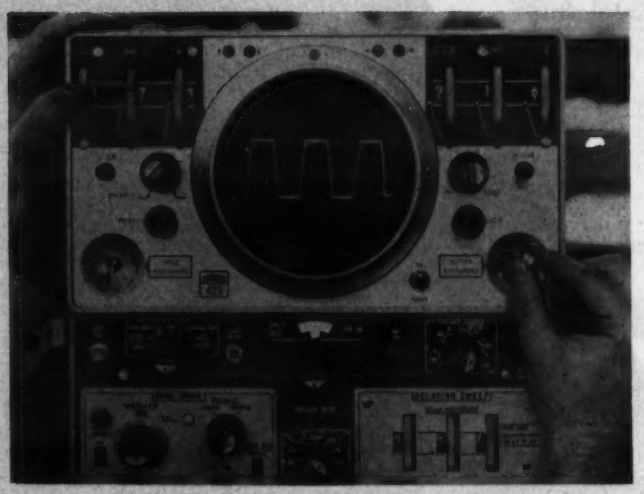

FIG. 2. **"HUMAN ENGINEERED"** to eliminate error in measurement, interpolation and correction for parallax in waveform analysis; the thumb-wheel operated digital Read-Out switches for Y and X positioning of the scaling dot speed accurate measurement.

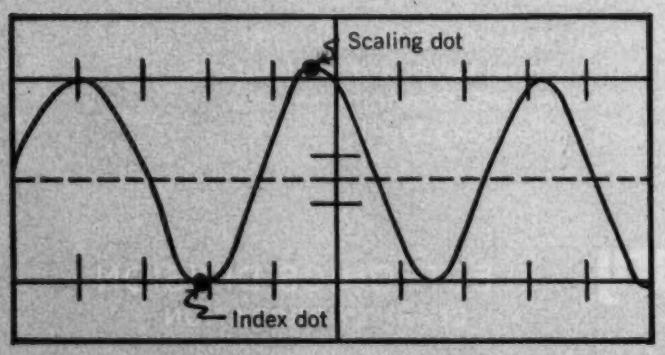

FIG. 3. **PEAK-TO-PEAK** voltage measurement on positive (left) and negative (right) slopes of waveform.

TECHNICAL TRAINING and electronic knowledge have been prerequisites in the use of cathode-ray oscilloscopes ever since the first of these versatile instruments was built by Dr. Allen B. Du Mont in 1931. Although only a few minutes of "knob-twiddling" will enable a neophyte to obtain interesting wave-forms on a conventional oscilloscope; skill and training are required for accurate readings which usually involve interpolations, and corrections for parallax. This requirement for operator skill has limited the usefulness of the conventional oscilloscope in many production and testing applications.

The new Du Mont 425 oscilloscope is an achievement in human engineering which provides a digital readout system operated by simple "joystick" controls and thumb-wheel indicators. These indicators provide direct number readings from the front panel of the scope while eliminating the possibility of human error through mathematical miscomputation or visual misinterpretation.

The readout system not only allows untrained personnel (Fig. 1) to use it with repeatable and unprecedented accuracy, but also provides electrical outputs which can directly tie into computers, recorders, punch-card machines and other data processing systems for statistical analysis or control.

From the standpoint of the electronics engineer, he now can save valuable time previously consumed in reading, measuring and interpolating standard visual oscilloscope signals, which often required multiple measurements and averaging for optimum results. Du Mont time studies have indicated that up to 40% of all engineering time, where use of an oscilloscope was required, was devoted to either reading or interpolation of waveform patterns. This time can now be devoted to other important laboratory and research procedures.

The new scope will also be welcomed by biological and medical reseachers as providing highly sensitive electro-medical instrumentation without requiring the close attention of an electronics technician.

Digital Scope Operation

The system is relatively simple to operate. On the face of the instrument (Fig. 2) six thumb wheels and a joy stick positioner control are used to move and position one indexing and one scaling dot, formed from a lissajou pattern of a properly-phased square wave, which are superimposed on the stationary wave-form pattern. The square wave is time shared into the X and Y axis alternately between the sweep and the Y signal. Because this insertion is made virtually at the inputs to the main frame amplifiers, any distortion in the amplifiers or the CRT equally effect the signal and the measurement, giving an accuracy far exceeding usual scale interpolations.

Operation of the index positioning joystick (left) moves both dots in unison during the positioning of the index dot (Fig. 3) to its base or reference position on the pattern. Movement of the scaling dot to the point on the pattern at which measurements are to be taken is then accomplished by three vertical thumb-switches (upper left, Fig. 2) and the three horizontal thumb-switches (upper right). Voltages and elapsed times are read directly from the ReadOut Switches. Positioning of the waveform pattern is also simplified by means of the single con-

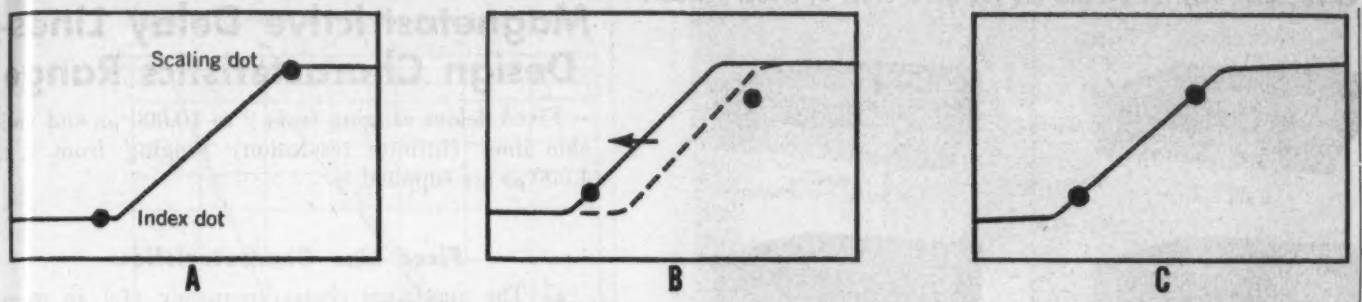

FIG. 4. **RISE TIME** Measurements are simplified.

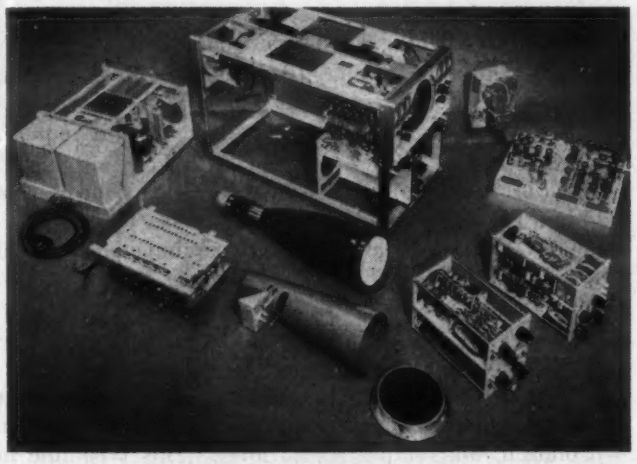

FIG. 5. **MODULAR CONSTRUCTION** of Du Mont 425 oscilloscope enables rapid servicing and guarantees protection against prolonged down-time and obsolesence. All modules are detachable by means of screws and pin connectors.

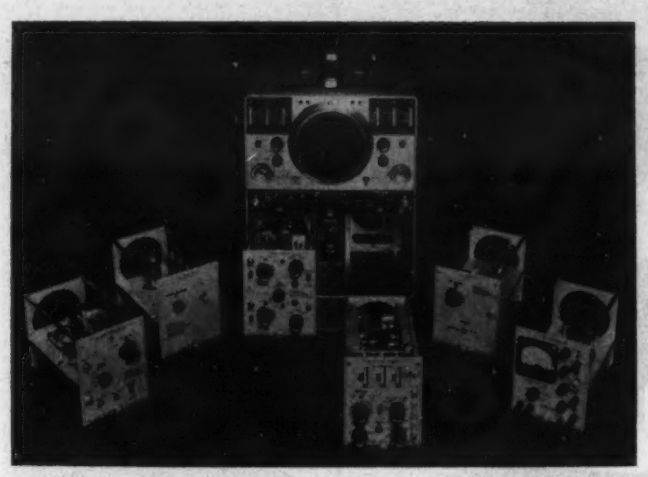

FIG. 6. **DOUBLE PLUG-IN** cavities now accommodate six different plug-in units, depending on customer's needs. Additional plug-in units are being developed to extend versatility of the instrument.

and printers. For remote analog devices such as computers and recorders, an analog voltage proportional to the digital reading may be taken directly from the scope.

Modular Construction

Five basic modules built into a main frame comprise the DuMont 425 (Fig. 5). This physical construction enables the user to eliminate costly retrol Pattern Positioning joystick (right).

Rise time measurements are equally simple. First, the indexing and scaling dots are positioned on the flat portions of the waveform just before and immediately after the rise pattern (Fig. 4a). The "10%-90%" button is then pushed to its hold position, automatically moving the dots to the 10% and 90% amplitude points. Using the Main Sweep Trig Level control, the wave form is shifted until it intersects the index dot (Fig. 4b). Now the X Readout thumb switches are used to move the scaling dot left until it intersects the waveform, and the accurate value of rise time appears on the X Readout switch (Fig. 4-c). Fall times are measured by switching to negative polarity and using the same technique.

The 40-pin connector plugs at the top of the Du Mont 425 chassis furnish direct tie-in with external data processing equipment, including card punches pairs and down-time by quick replacement of any damaged module. Each module is an individual electrical and mechanical entity.

Design of the distributed amplifier is typical of the new features used throughout. This module uses a twin-tetrode with single cathode sleeve which establishes wide-band characteristics, eliminates cathode-lead inductance and provides higher input impedance at higher frequencies. This non-critical circuitry also eliminates all need for preselection of replacement tubes. A highly refined constant resistance filter section and a canted tube alignment for prevention of capacitive coupling are other stablizing features. All components are standard types, and precision resistors and tubes having 10,000-hour mean-time-to-failure ratings ensure long trouble-free life.

The Du Mont 425 scope provides two plug-in facilities instead of the single plug-in afforded by previous instruments (Fig. 6). Interchangeable units for X functions include extremely wide range delaying sweep, and X-amplification. The Y plug-ins now range from a 50 mv/cm, 33 mc input dual trace amplifier to a 500 μv/cm, 3-5 mc unit of high stability and balanced input. Signal generators, passive delay units with resolution to 1 x 10^{-10} sec, wide band sampling scopes, and power access plug-ins will soon be available.

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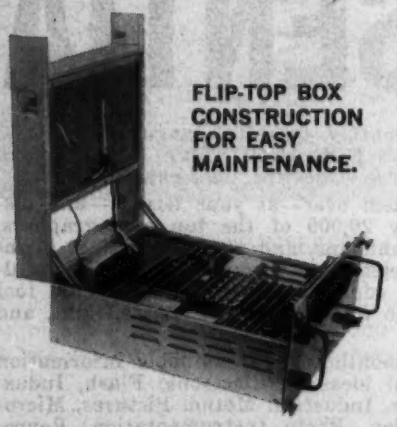

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- 50 readings per second, average
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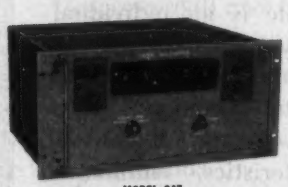
DC Volts/DC Ratios

MODEL 841
DC Volts/DC Ratios/Resistance

MODEL 842
DC Volts/DC Ratios/AC Volts

MODEL 843
DC Volts/DC Ratio/AC Volts/Resistance

MODEL 844
DC Volts/Ratio/DC Pre-Amplifier



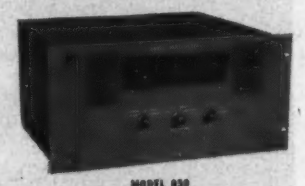
MODEL 845
DC Volts/Ratio/Resistance/DC Pre-Amplifier

MODEL 846
DC Volts/Ratio/AC Volts/DC Pre-Amplifier

MODEL 847
DC Volts/Ratio/AC Volts/Resistance/Pre-Amplifier

MODEL 848
DC Volts/Ratio With Electrical Outputs

MODEL 849
DC Volts/DC Ratios/Resistance With Electrical Outputs



MODEL 850
DC Volts/DC Ratios/AC Volts With Electrical Outputs

MODEL 851
DC Volts/DC Ratio/AC Volts/Resistance With Electrical Outputs

MODEL 852
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MODEL 853
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MODEL 854
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MODEL 855
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Many variations of these basic models including AC ratiometers, milliohmmeters, microvoltmeters and specialized measuring instruments tailored to individual systems requirements are available in the same physical configurations. *Ask your EI sales office or representative for complete specifications today!*

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CIRCLE 7 ON READER-SERVICE CARD

Magnetostrictive Delay Lines—Design Characteristics Range

Fixed delays ranging from 2 to 10,000 μs and variable lines (infinite resolution) ranging from 2 to 4,000 μs are supplied.

Fixed Line Characteristics:

a) The maximum center frequency (f_c) in megacycles vs delay time for fixed delay lines is shown in Fig. 1. Maximum f_c for lines less than 260μs is 1.4 mcs.

b) Bandwidth at the 3db point is ($f_c \pm .5f_c$).

c) Optimum input pulse length is ½ f_c in microseconds, where f_c is in megacycles.

d) Maximum pulse repetition rate is equal to ($f_c \pm .5f_c$).

e) Maximum signal output vs delay time is shown in Fig. 1 when using optimum pulse length, 20v pk pulse amplitude, and a transducer impedance of 1000 ohms.

Taps

a) Lines greater than 500μs in delay must use torsional mode to secure maximum compactness, resolution, and output signal levels. This type line may be tapped to provide a signal 10db below the signal level shown Fig. 1. Each tap will reduce the line energy 3db, so that each succeeding tap will have 3 db less signal output. The end terminating output shown in Fig. 1 will be reduced 3 db for each tap used. Taps may use a minumum spacing of 1 μs.

b) Lines less than 500 μs may use the longitudinal mode which enables as many taps as desired up to a minimum spacing of 0.25 μs between taps and a minimum spacing between input and the 1st tap of μs. Longitudinal mode taps do not attenuate signals on succeeding taps, hence all outputs are substantially equal except for a line loss of 3db/millisecond delay.

Variable Delay Lines

a) Newly developed transducers enable multi-turn continuously variable delay lines up to approximately 400 μs and down to 2 μs minimum.

b) Signal output is approximately 20 db lower than that shown in Fig. 1 for a given delay.

c) Center frequency, f_c is approximately 50% of that shown in Fig. 1 for a given delay.

d) Variable lines less than 50 μs may use straight line construction with a screw thread adjustment.

Total delay and tap positions may be provided with delay adjustments, usually amounting to $\pm 4\mu$s.

Range of input and output impedances may be between 50 and 1000 ohms.

Temperature

a) CEC Magnetostrictive delay lines are capable of withstanding continuous operation between −55°C and +85°C. The line material is aged and stress

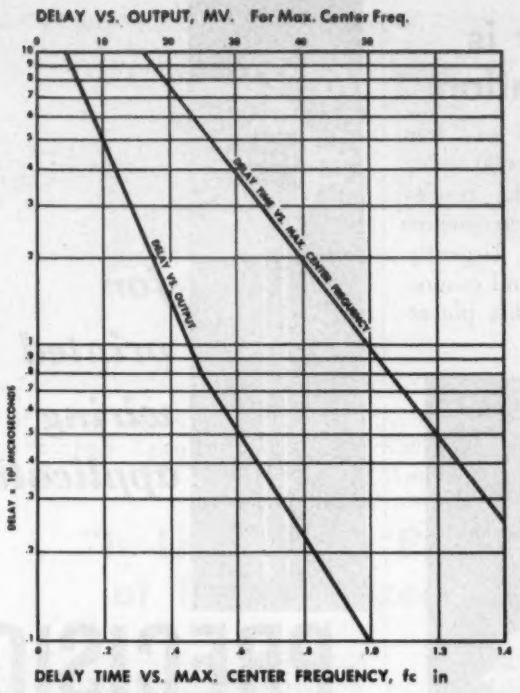

DELAY VS. OUTPUT, MV. For Max. Center Freq.
DELAY TIME VS. MAX. CENTER FREQUENCY
DELAY VS. OUTPUT
DELAY x 10⁶ MICROSECONDS
DELAY TIME VS. MAX. CENTER FREQUENCY, fc in

FIG. 1. MAGNETOSTRICTIVE delay line characteristics based on optimum resolution and signal output level.

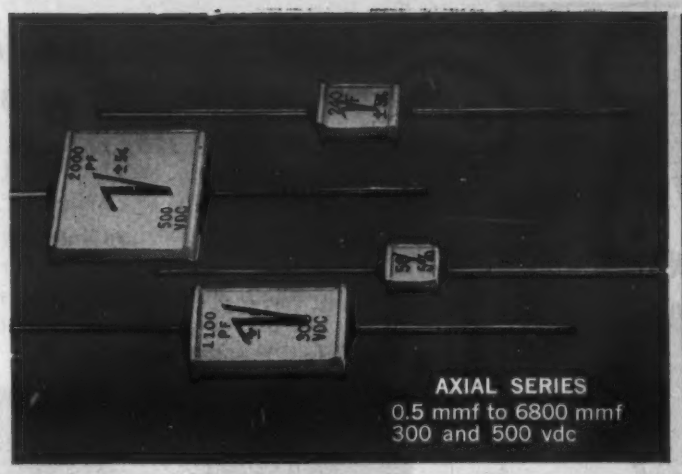
relieved to insure permanent stability. By careful selection and heat treatment of special alloy delay line material temperature coefficients up to 1 PPM/°C can be supplied. Specific temperature delay coefficients can be supplied to offset system delay variations.

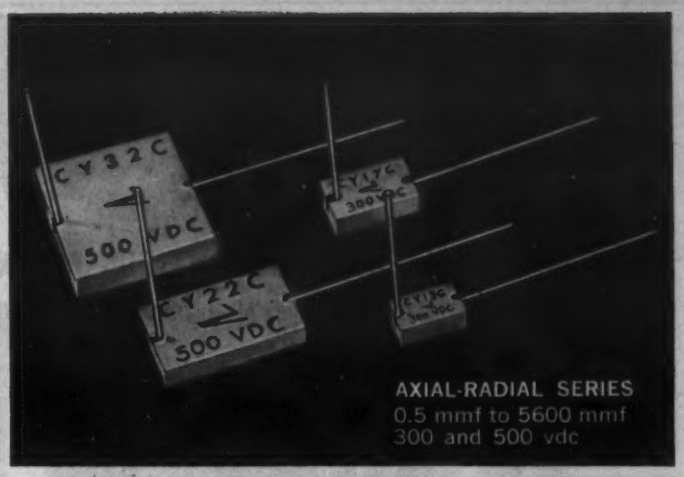
b) Amplitude temperature coefficients: Because efficiency of the magnetostrictive line decreases as temperature drops, the amplitude change from 0°C to 50°C will change approximately 3 db for short lines (less than 100 μs) and will increase about 2 db for each additional 100 μs delay. When necessary thermistor compensation can be provided to maintain output signal level within ± 1 db from 0°C to 50°C. It is recommended that some form of automatic gain control be used when wider temperature ranges are encountered. If transistor amplifiers are used, then thermistor compensation may offset both gain changes in line and amplifier. CEC is equipped to engineer and manufacture line and amplifier combinations compensated to give the most economical time delay accuracy.

Maximum Characteristics

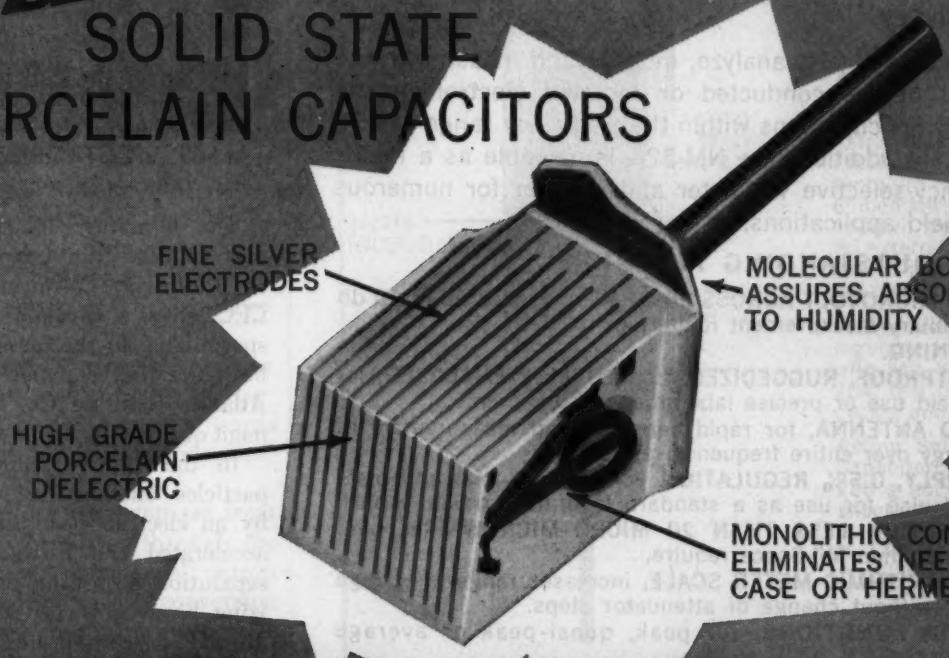
Characteristics shown in Fig. 1 represent compromises between resolution and signal output level. Higher resolution (higher f_c) can be secured at the expense of lower output. An increase in f_c requires extreme miniaturization of transducer elements (thus increasing the cost of the line). Lines less than 500μs can be supplied with f_c as high as 4 mcs and bandwidth of 4 mcs at the 3 db points. (*From 2-page data sheet on applications of magnetostrictive delay lines in analog and digital computers, radar systems, missile systems, etc.—Control Electronics Co., Inc.,* 10 *Stepar Pl., Huntington Station, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 92 ON READER-SERVICE CARD





Vitramon®
SOLID STATE
PORCELAIN CAPACITORS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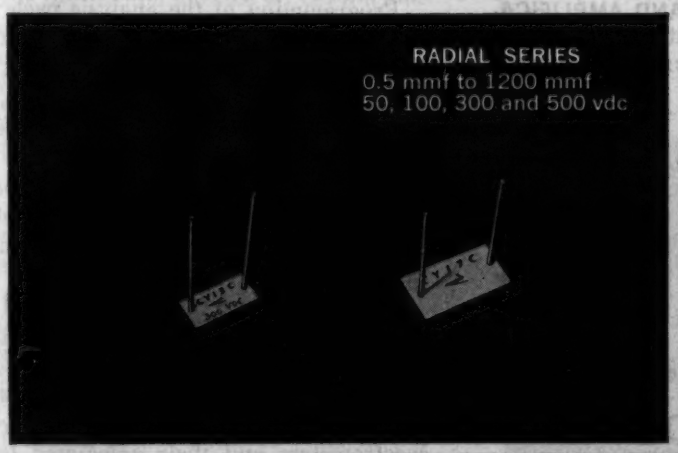
MONOLITHIC CONSTRUCTION ELIMINATES NEED FOR CASE OR HERMETIC SEAL

CUTAWAY OF AXIAL CAPACITOR



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The exclusive "Vitramon" Process fuses fine silver electrodes within a solid block of dense dielectric porcelain to form an integral monolithic unit with outstanding electrical and physical properties.

The molecular bond of dielectric, electrodes and terminals assures absolute immunity to humidity, low loss, low drift and great stability over a temperature range of —55°C to 200°C.

True reliability is inherent in the solid-state construction of all "Vitramon" porcelain capacitors. They are used extensively where quality, precision and dependability are imperative.

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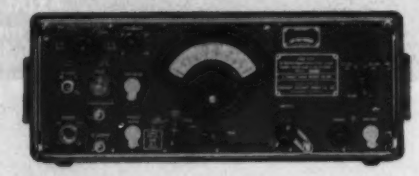
CIRCLE 8 ON READER-SERVICE CARD

NEW

RADIO INTERFERENCE — FIELD INTENSITY MEASURING EQUIPMENT, 375 mc to 1000 mc



The NEW NM-52A RI-FI instrument developed by STODDART to government specifications is now ready for immediate delivery.

Its purpose is to investigate, analyze, monitor and measure to the highest practical degree conducted or radiated electromagnetic energy to military specifications within the frequency range of 375 mc to 1000 mc. In addition, the NM-52A is valuable as a highly sensitive frequency-selective voltmeter and receiver for numerous laboratory and field applications.

OUTSTANDING FEATURES

SENSITIVITY OF 1 MICROVOLT ACROSS 50 OHMS, provides up to 40 db more than Military Measurement Requirements.
SINGLE KNOB TUNING.
RAINPROOF, DUSTPROOF, RUGGEDIZED AND TOTALLY ENCLOSED, for all-weather field use or precise laboratory measurements.
NEW BROADBAND ANTENNA, for rapid detection and measurement of radiated energy over entire frequency range.
NEW POWER SUPPLY, 0.5% REGULATION, for filament, bias and plate voltages, and also for use as a standard laboratory power supply.
OSCILLATOR RADIATION LESS THAN 20 MICRO-MICROWATTS, over 20 times better than Mil-Specs require.
TWO DECADE LOGARITHMIC METER SCALE, increases range of voltage measurement without change of attenuator steps.
THREE DETECTOR FUNCTIONS, for peak, quasi-peak or average measurements.
PORTABLE OR RACK MOUNTING, no modification required for laboratory, mobile, airborne or marine installation.
I-F OUTPUT FOR PANORAMIC DISPLAY OR NARROW BAND AMPLIFICATION, for visual presentation or increased sensitivity.
OVER 100 DB SHIELDING EFFECTIVENESS, increases measurement capabilities in presence of strong fields.
VISUAL PEAK THRESHOLD INDICATOR, for accurate slide-back peak voltage measurements.
CONSTANT BANDWIDTH OVER ENTIRE FREQUENCY RANGE.

The NM-52A now joins the family of STODDART government approved RI-FI instrumentation covering the frequency range of 30 cps to to 10.7 kmc to provide the finest RI-FI measuring equipment.

Basic Design + Good Instrumentation = Electronic Compatibility

serving 33 countries in Radio Interference control

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CIRCLE 9 ON READER-SERVICE CARD

Satellite Spectrometer is Triumph in Miniaturization

Upper atmosphere ions, molecules, atoms and free radicals inhabiting the region from 150 to 600 miles above the earth will be analyzed and the results telemetered to earth by miniature mass spectrometers inside a NASA satellite scheduled for 1961. Urgently needed information on the effects of solar and cosmic energies on the atmosphere surrounding this planet should result from this study.

MASS SPECTROMETER weighing only 12 lbs. analyzes ions of mass 1 to 32 while satellite-borne.

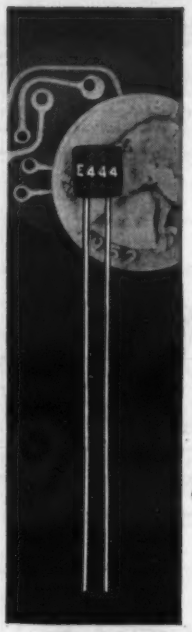
The miniature laboratory is being developed in prototype by the Consolidated Systems Corporation of Monrovia, California, whose parent corporation, CEC, now a division of Bell & Howell, has been specializing in the mass spectrometry field since they built the first commercial mass spectrometer for the Atlantic Refining Co. in 1942 to speed the development of aviation fuel.

In the 12-lb satellite mass spectrometer, neutral particles outside the satellite shell will be ionized by an electron beam from a rhenium filament, then accelerated and directed into a magnetic field for separation according to their masses. When the ionizing beam is turned off, ions can be admitted and directly measured. Permanent magnets are used for the analyzing field to conserve weight and operating current.

Programming of the analysis cycle is accomplished by changing the acceleration potential of the analyzer. Mass range for the instrument will be from 1 to 32, to encompass hydrogen atoms, nitrogen atoms and molecules, oxygen atoms and molecules and water vapor. The programmer is a binary solid-state logic system about the size of a cigarette package. An electrometer amplifier will raise the level of ion current signals as low as 10^{-16} ampere to an amplitude adequate for telemetry.

Two spectrometers will be housed in the 35-inch diameter satellite to ensure a favorable ion-entry aspect at all times, and the analysis is expected to continue without pause for at least a year. Batteries charged from solar cells will supply power for the spectrometers and their associated telemetry circuits for transmission of the data back to the earthbound scientists.

FOR MORE INFORMATION CIRCLE 93 ON READER-SERVICE CARD



for printed wiring applications

PRECISION

wire-wound resistors

Improved design in Cinema's CE400 resistors offer superior performance characteristics and greater ease of installation in printed-wiring boards. Microminiature in size these precision units are ideal for use in critical applications where space is at an absolute premium.
Encapsulated in epoxy, the meniscus effect of this material is used to excellent advantage at the terminal wires to prevent the resistor from being drawn flush to the printed-wiring board and eliminates the possibility of capillary-effects experienced in soldering and high humidity environments. Performance characteristics as per MIL-R93B and MIL-R-9444. CE400 resistors are available in the following sizes and ratings:

TYPE	WATTAGE RATING	DIA.	LENGTH	MAX. RESISTANCE
CE444E	.25	1/4"	5/16"	600K
CE445E	.25	1/4"	1/2"	900K
CE446E	.5	1/4"	3/4"	1.7 Meg.
CE447E	.5	3/8"	3/4"	5 Meg.
CE451E	.6	1/2"	5/8"	6.5 Meg.

Also available in axial lead types as CE200 Series. Write for complete technical details to...

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DIVISION AEROVOX CORPORATION
1100 Chestnut, Burbank, California

CIRCLE 10 ON READER-SERVICE CARD

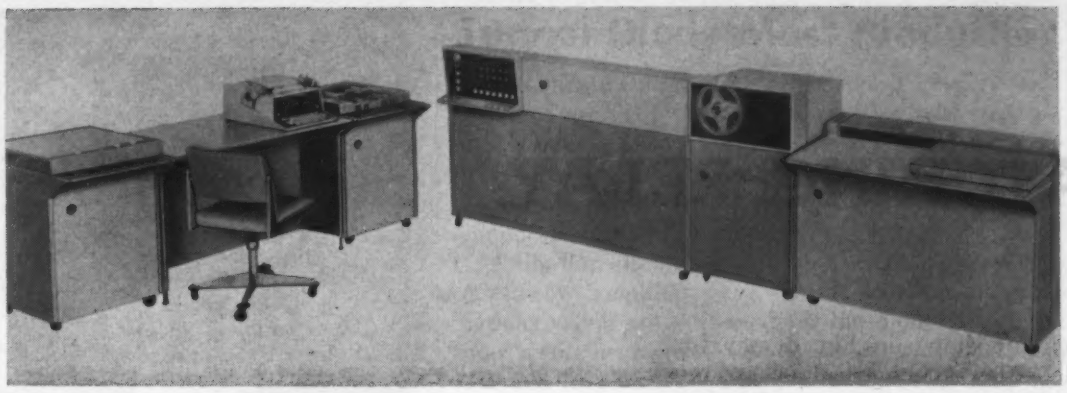


FIG. 1. IN-LINE DATA PROCESSING System RPC-9000 includes (left to right): RPC-9410 Photo Electric Punched Tape Reader, RPC-9500 Tape Typewriter, RPC-9010 Computer, RPC-4440 Tape Punch, and RPC-9100 Magnetic Tape Drum.

"In-Line" Data Process is New Concept of Transistorized Modular Computer

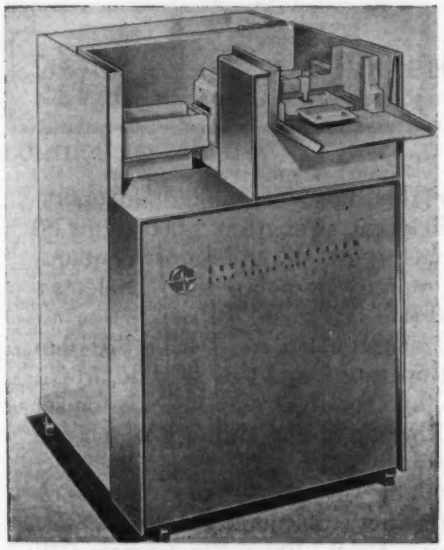


FIG. 2. AUXILIARY ACCESS UNITS include the RPC-9460 Rapid Punched Card Reader (above) and the RPC-9450 Line Printer (below) with speeds to 1000 lines per minute.

A new modular electronic data processor which accepts data in random order, automatically updating all affected records in a single uninterrupted sequence of operations, is designated the RPC-9000 system (Fig. 1). Said to be equally applicable to the needs of payroll, inventory control, production control, accounts receivable and payable, sales analysis and forecasting, its capacity can be indefinitely extended by the addition of external memory magnetic tape loops, each storing up to 1-million alpha-numerical characters. The new computer is a development of the Royal Precision Corporation.

The internal operating memory consists of nine blocks of magnetostrictive delay lines capable of storing 816 instructions or 136 twelve-character words of data. This may be expanded to approximately 2000 internally stored instructions, or 328 words.

Information can be entered into the computer from punched paper tape, punched cards, or through the typewriter keyboard. Forty-three "commands" permit flexibility in programming and no binary conversion is necessary for machine computation. Auxiliary units to speed input and output access (Fig. 2) include the RPC-9460 photoelectric punch card reader with a speed of 500 cards per minute and the RPC-9450 Line Printer with speeds up to 1000 lines per minute (each line consisting of 120 alphanumeric characters).

Separate buffers speed cross-communications between input units, computer and output units, allowing multiple input, multiple search and multiple output operations. Eight separate records may be reached simultaneously. Up to 30 input and output units may be operated simultaneously "on line".

As with other RPC transistorized data processing systems, no air conditioning and little or no site preparation are required. Operating from ordinary house current, the entire system is protected from power failure by a built-in emergency power supply which continually floats "on-line". It will be available through lease, lease with option to purchase, or outright purchase through offices of the Data Processing Division, Royal McBee Corporation, Port Chester, N. Y.

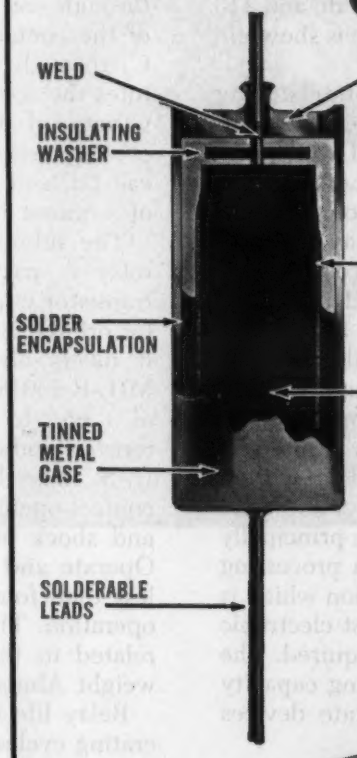
FOR MORE INFORMATION CIRCLE 94 ON READER-SERVICE CARD

NO. 1 OF A SERIES

ASTRON SOLID TANTALUM CAPACITORS

rugged

WITHSTAND *vibration* TO 2000 CYCLES AND 35 G'S.



In the construction of the Astron Tantalum Solid Electrolyte Capacitor, the tantalum anode is firmly embedded in solder and solidly fixed in the case. There are no external welds, and the tinned leads can be bent adjacent to the case.

Production capacitors are regularly tested in accordance with MIL-STD-202A, Method 204, test condition B, to 2000 cycles and 15 g's.

Astron Solid Tantalum Capacitors have withstood 200 g acceleration and 150 g shock tests.

- 125°C operation.
- Rugged construction.
- Capacitance stability.
- Subminiature.
- Dry, solid construction.
- Meets MIL specifications.

FOR COMPLETE INFORMATION WRITE TODAY FOR BULLETIN E-675A AND FOR ASTRON'S DESIGN ENGINEER PUBLICATION, TECHNIQUES, VOL. 59, NO. 2

ASTRON CORPORATION

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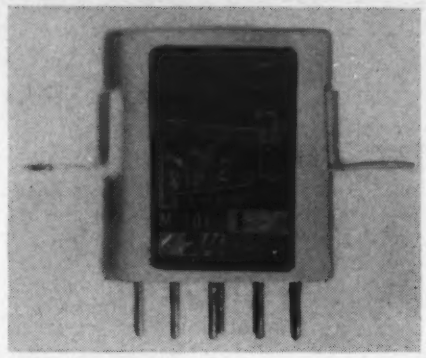
SPECIALISTS IN CAPACITOR MINIATURIZATION

CIRCLE 11 ON READER-SERVICE CARD

DUAL-COIL MAGNETIC LATCHING RELAY



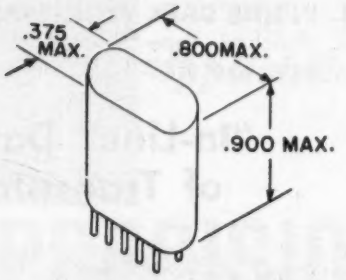


FIG. 1. BISTABLE Latching Relay of high stability has capability as missile logic element.

A NEW half-ounce polarized crystal-case relay meeting MIL-Spec requirements is well qualified for use in a large number of critical applications. Dual coils provide a "set-reset" capability, an Alnico V magnet provides a bi-stable latching characteristic and contact pressures of 16 grams minimum. The contact configuration is 2PDT, with contact rating of 2 amp resistive at 28 v dc and 115 v ac. The plug-in, bracket-mounted type is shown in Fig. 1.

Designated the M101 series magnetic latching relay, it performs as a set-reset memory element, with truth table as shown in Fig. 2. A 1-watt pulse of 3 milliseconds duration applied to the appropriate coil will transfer the armature position. If greater sensitivity is required the coils may be connected in series and the reset function accomplished by reversing the polarity of the applied pulse. Although continued application of power after transfer of contacts is not necessary, the coils are engineered to withstand continuous operation.

In the bistable memory circuit shown in Fig. 3, positive input pulses of 5 milliwatts for 3 milliseconds are capable of operating the relay, with a single coil power supply providing the set and reset functions. Applications of this circuit lie principally in the input and output devices of data processing equipment where a frequency of operation which is intermediate in speed, between ultra-fast electronic circuits and slow manual response, is required. The relay also provides higher power-handling capacity than is afforded by low-current solidstate devices for driving electromechanical devices.

Timing Cycle Operation

The dual coil feature of the M101 relay lends itself to the generation of self-timed cycling devices. Constants of the circuit shown in Fig. 4 may be selected to provide either symmetrical or assymmetrical cycles. In the position shown, application of the input voltage will cause the capacitor C_1 to charge through timing resistor R_1 until the peak emitter voltage of the unijunction transistor T_1 is reached. At this point T_1 triggers, discharging C_1 through coil B which operates the relay. Transfer of the contacts results in application of voltage to C_2 through R_2 and T_2 is triggered, which constitutes the second phase of the timing cycle. A wide variety of timing cycles is possible, providing cycling periods up to 60 seconds duration which can be held to close tolerances over a wide range of ambient temperatures.

The subminiature size and weight of the M101 relay is particularly adapted to packaging with transistor circuitry, with a plug-in header designed for printed circuit applications. Hermetically sealed, it meets all the environmental requirements of MIL-R-25018B, operating over an ambient range of −65° to 125°C. Typical performance characteristics indicated during qualifications testing at U. S. Relay-Electronics testing facility include no-contact-opening during vibration of 30G to 300 cps and shock of 100G for 11 milliseconds duration. Operate and release times have been recorded at less than four milliseconds in the normal mode of operation. This rapidity of operation is said to be related to the high-efficiency of the strong, light weight Alnico V-biased magnetic circuit design.

Relay life is rated at a minimum of 100,000 operating cycles at 125° at rated load, with mechanical life in the neighborhood of one-million operations. Sea level dielectric strength is 1,000 v rms 60 cps for all terminals to ground and across contacts, derating to 800 v rms after life test. Dielectric strength at 71,000 ft is 500 v.

The basic units of the M101 series have 630-ohm coils for nominal operation at 24 to 28 v dc. Maximum pick-up voltage for this relay is 18 v for set and reset coils. Other operating voltages which can be provided include 6 v, 12 v, 36 v, and 28 v dc. Headers are available in plug-in or solder-hook types, each in a variety of mounting styles. The Engineering Dept., U. S. Relay-Electronics, 717 No. Coney Ave., Azusa, Calif., developers of the M101 series, anticipate that its unusual and versatile characteristics will suggest many applications to component and systems design engineers, and invite correspondence on specific requirements and requests for design proposals.

FOR MORE INFORMATION CIRCLE 95 ON READER-SERVICE CARD

TRUTH TABLE

AT TIME t		AT TIME (t+1)			
		CONTACT PAIRS			
COIL "A"	COIL "B"	C	D	E	F
1	0	1	0	1	0
1	1	C^t	D^t	E^t	F^t
0	0	C^t	D^t	E^t	F^t
0	1	0	1	0	1

FIG. 2. LOGIC Truth Table for M101 relay shows latching sequence for relay contacts. Exponent t (C^t) indicates that the state of contact does not change as a result of the input signal indicated.

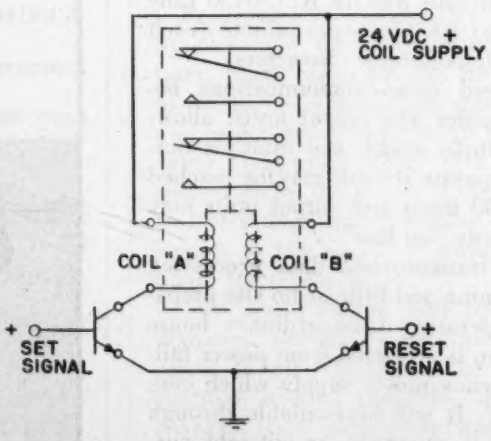


FIG. 3. POSITIVE signal pulses of 3 milliseconds duration are sufficient to set or reset this bistable memory circuit.

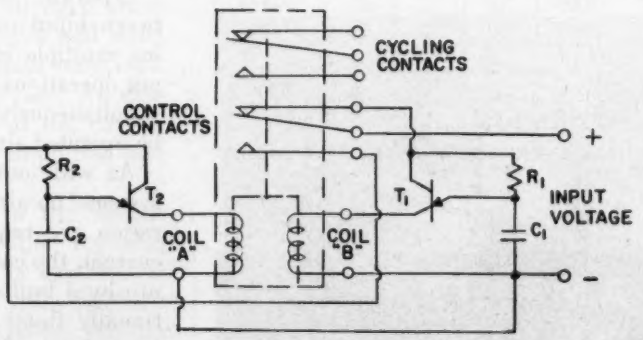


FIG. 4. SELF-TIMED cycling circuit generates symmetrical or asymmetrical timing cycles with either phase as short as 4 ms or as long as 1 sec, depending on the RC time constants.

CONTROLLED SOLID STATE TIMING MODULES

Originally developed and produced for use in Tempo's service-proven Time Delay Relays and other timing systems, these modules are now available as individual "building block" units. Their sub-miniature size and weight, plus excellent resistance to severe environmental conditions, make them particularly suitable for missile, spacecraft and other critical applications.

CONTROL VERSATILITY

The basic module provides a precise time delay between application of input voltage and turn-on. A unique 'set-reset' control line is included to allow instantaneous turn-on or turn-off at any time without interrupting the input voltage. By employing the control line function, together with the application of various standard logic blocks, a wide variety of precision timing devices and controls can be constructed by the user. Typical of these are: Logic Function Time Delay Devices, Electronic Stepping Switches, Multi-Channel Pulse Programmers, Repeat Cycle Timers, Pulse Train Generators.

FIXED OR ADJUSTABLE TIMING

Both fixed and adjustable time modules are available. In fixed types, delay periods may be specified from .00005 seconds to 300 seconds. In the adjustable types, the minimum adjustment range available is from .00005 to .001 seconds — the maximum is from 15.0 to 300 seconds. Fifteen intermediate ranges are also available, each with a 20 to 1 spread. Adjustment is made by a simple, quick change of an external resistance value—*no special calibration equipment or elaborate procedures are required.*

GUARANTEED ACCURACY

Accuracy ratings of 10%, 5% or 3% are available in fixed types; 10% or 5% in adjustable types. These timing accuracies are guaranteed under any combination of operating and environmental conditions including:

Input Voltage	18 to 31 vdc
Temperature	−55°C to +125°C
Vibration	20 g's, 2000 cps
Shock	50 g's, 11 millisec.
Acceleration	20 g's, steady state

Maximum load current rating is 100 milliamps resistive. Units are available to switch the load to ground or switch power to the load. A typical module, housed in a 1-inch cube case, weighs only a fraction more than 1 ounce. *Special-order types are available for other requirements of delay times, accuracy and load ratings, switching action, etc.*

Write For Engineering Bulletin 5906
Complete technical description and specifications plus detailed 'how-to' information on circuit and system applications.

These highly engineered modules are manufactured in compliance with Tempo's exacting Quality Assurance Program, including functional testing of each unit under all combinations of rated temperature and voltage extremes.

tempo

TEMPO INSTRUMENT INCORPORATED
3 Commercial St., Hicksville, L. I., N. Y.

CIRCLE 12 ON READER-SERVICE CARD

Tunnel Diode Mass Production

The quantity production of the new Tunnel (Esaki) Diode, Type TD-1 Germanium, together with new low prices announced by the General Transistor Corporation is expected to spur extensive experimentation and applications development work using the new semiconductor units.

A flip-flop circuit (Fig. 1) and a negative resistance microwave amplifier (Fig. 2) are two typical applications which are suggested for the diodes which are now available in two peak-to-valley ratios; 3:1, and 7:1 and higher.

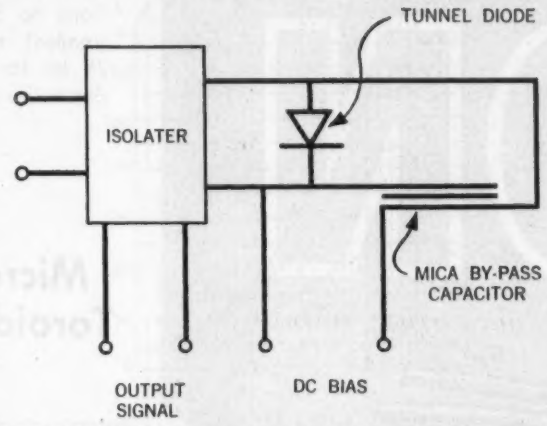
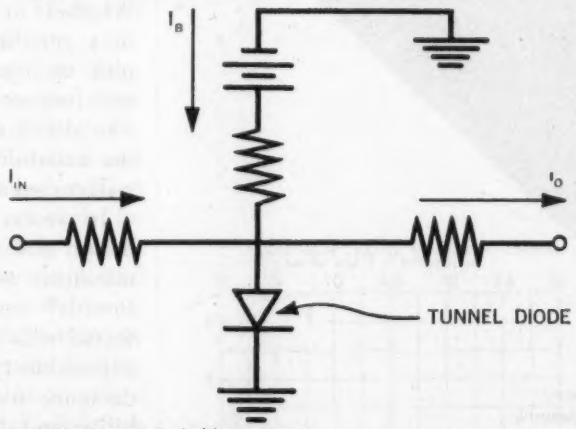


FIG. 1. TUNNEL Diode in a Flip-Flop circuit.

FIG. 2. NEGATIVE RESISTANCE microwave amplifier using tunnel diode.



I_B is the tunnel diode bias current

Prices quoted for the two ratios are $8 and $10 respectively, per unit, which are said to be possible because of the excellent production yields which have been experienced. Typical electrical characteristics for the low-ratio TD-1 diode are as follows:

Voltage @ peak current	45 mv.
Voltage @ minimum current	200 mv.
Negative resistance (−R)	100 ohms
Capacity (C)	50 $\mu\mu$f
Series Inductance (L_s)	8 mμh
Series Resistance (R_s)	1.5 ohm
Resistive cut-off Frequency (f_r)	0.26 kmc
Self-resonant frequency (f_{sr})	0.23 kmc

(*From 2-page specification sheets, FD-1 Tunnel Diode, General Transistor Corp.*, 91-27 138*th Place, Jamaica* 35, *N. Y.*)

FOR THIS LITERATURE CIRCLE 96 ON READER-SERVICE CARD

and number
are nothing
but
modes of thought
or rather
of imagination"

BENEDICT SPINOZA, Dutch Philosopher, 1632-1677

It is quite probable that most people today think of and define Time in considerably more finite terms than did Spinoza, and they would immediately express their disagreement with that eminent philosopher. Yet a philosophy as all-encompassing as Spinoza's should not, because of its seemingly unreal, intangible nature, be hastily dismissed. Instead, it should serve to stimulate no small measure of lively thought and discussion. **Tempo Instrument Incorporated**, Hicksville, L. I., New York

DESIGN AND MANUFACTURE OF PRECISION ELECTRONIC TIMING DEVICES AND CONTROLS

CIRCLE 13 ON READER-SERVICE CARD

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CIRCLE 14 ON READER-SERVICE CARD

FIG. 1. ADJUSTABLE TOROIDAL reactances down to microminiature sizes are available in new additions to Burnell Adjustoroid line. ATE-34 (left) is smallest member, provides Q of more than 55 at 25 kc for printed circuit applications. ATE-12 is dimensionally identical with ATE-11.

Microminiature Adjustable Toroids Tune Printed Circuits

OPTIMUM PERFORMANCE of tuned circuits, phase networks and similar impedance devices depends on precise adjustments of circuit reactances. Whether or not the required reactance is available in a certified, fixed value of capacitor or inductor, pick up from other circuit components may change the frequency response of the impedance network. The ability to quickly trim circuit reactances enhances the reliability of the completed system and greatly reduces subsystem test rejections.

In recent years, Burnell & Co., pioneers in the design and manufacture of sub-miniature and microminiature toroids has developed a variety of Adjustoroids® each of which contains an actual complete toroid with all the excellent characteristics of the non-adjustable types including high Q, low change in inductance with dc current variation, temperature stability and freedom from external field effects. Adjustment is obtained by a completely stepless function, using magnetic biasing. The nominal inductance

®Pat. 2,762,020

TABLE 1. BURNELL ADJUSTOROIDS ELECTRICAL AND PHYSICAL CHARACTERISTICS

	Dia.	Hgt.	Wt. (oz.)	Useful Freq. Range (kc)	Frequency at Max Q (kc)	Max L (in hy)
ATE 0	1-1/16"	1"	1.5	1 to 20	10	5
ATE 4	1-5/16"	1-3/16"	3.5	1 to 16	6	15
ATE 6	1-1/16"	1"	1.5	10 to 100	30	.75
ATE 10	1-5/16"	1-3/16"	1.0	3 to 50	20	.75
ATE 11	3/4"	13/16"	0.75	2 to 25	15	5
ATE 12	3/4"	13/16"	0.75	15 to 150	60	1
ATE 34	27/64"	21/32"	0.1	3 to 30	55	1

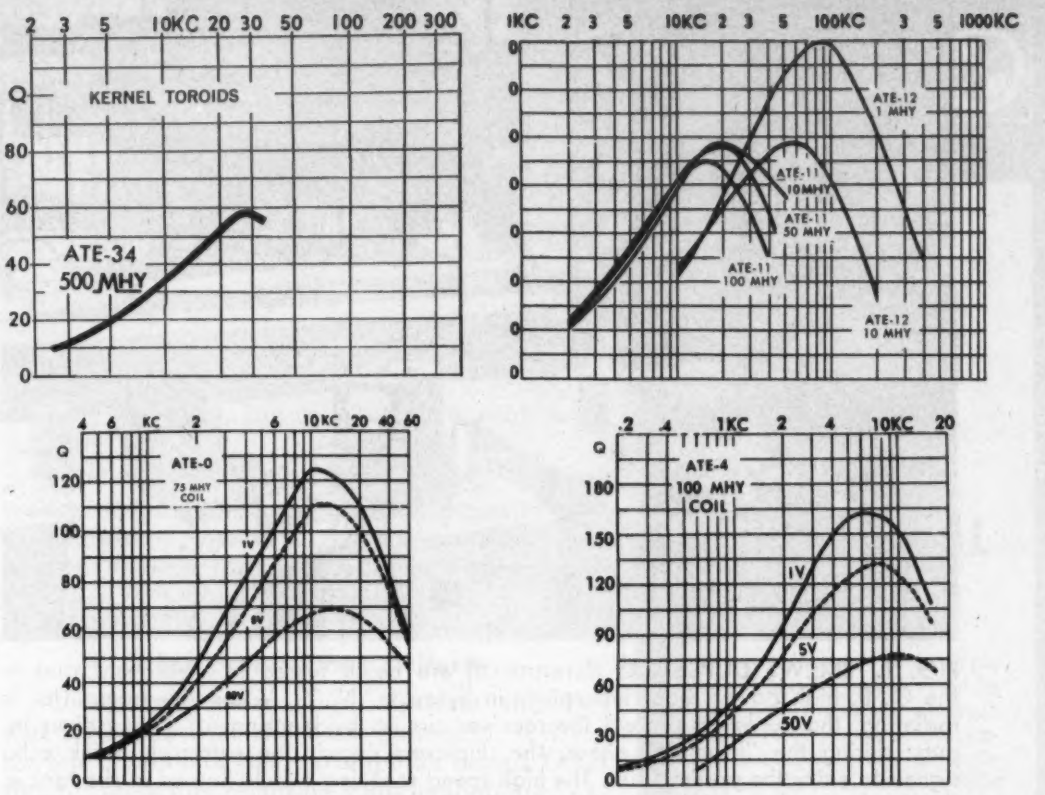


FIG. 2. Q vs FREQUENCY characteristics for Adjustoroids. Horizontal scales are in kilocycles. Q is indicated in vertical units.

value with a tolerance of ±2% is the maximum value for an Adjustoroid.

Latest and newest developments in the Burnell Adjustoroid line are the microminiaturized Kernel ATE 34 and the sub-miniature ATE 11, ATE 0 and ATE 4 (Fig. 1). These Adjustoroids have the additional and unique virtue of being slotted for screw driver adjustment. Thus, they can be set to the exact value needed *after* connection in the circuit. Both the new microminiature Kernel ATE 34 Adjustoroid and the sub-miniature types ATE 11, ATE 0 and ATE 4 are variable over a ten per cent range of their inductance. Fully encapsulated and hermetically sealed, they ruggedly withstand high acceleration, shock and vibration environments.

Because they offer a valuable contribution to printed circuit and modular designs, they should have wide commercial and military applications in phase networks, variable transformers, oscillators, discriminators, variable tuned circuits, etc.

The Kernel ATE microminiature Adjustoroid is particularly designed for printed circuit applications, with terminal spacings of 0.300", and meets specifications MIL-T-27 Grade 4 Class R and MIL-E-15305A.

Physical and general electrical characteristics of the newest Adjustoroids are shown in Table 1, while Q vs Frequency relationships for various inductance settings of the Slot-head Adjustoroids are shown in Fig. 2. Typical effect of dc on inductance is shown as a percentage of decrease in inductance for types ATE-0 and ATE-4 in Fig. 3.

The newest members of the Burnell Adjustoroid family were on display at the recent New York IRE Show. A bulletin giving additional data and characteristics on Adjustoroids is available from Burnell & Co., 10 Pelham Parkway, Pelham, N. Y.

FOR MORE INFORMATION CIRCLE 97 ON READER-SERVICE CARD

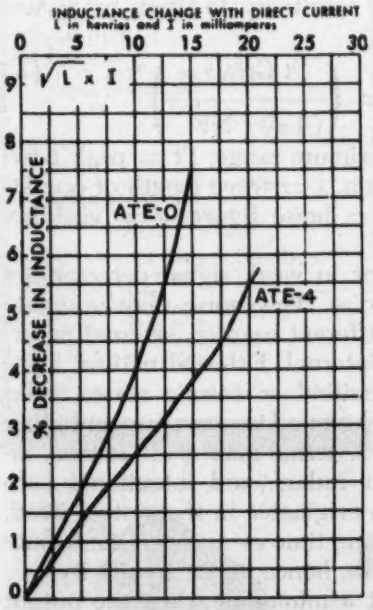
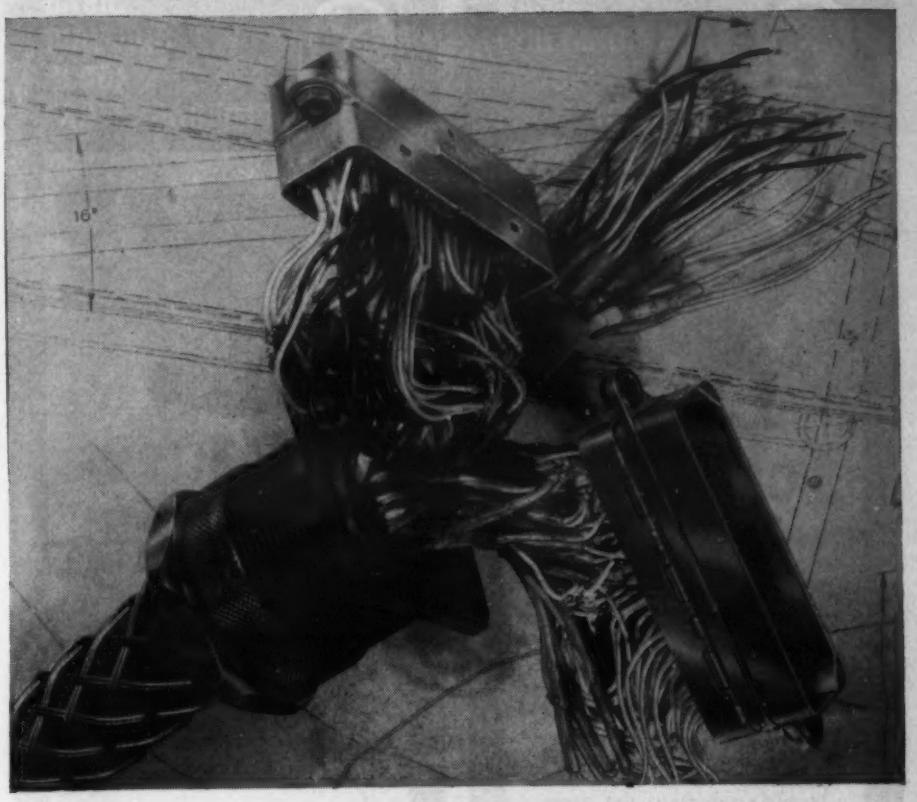
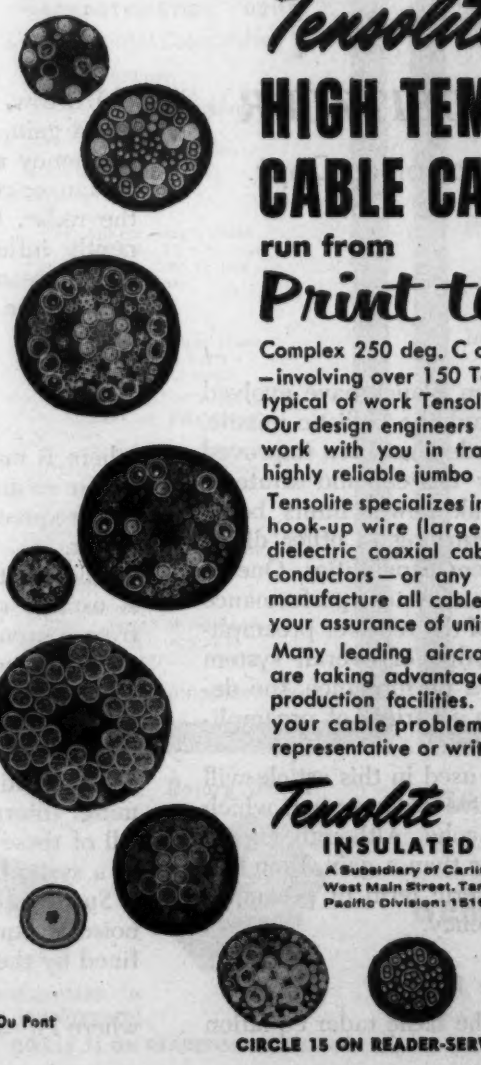


FIG. 3. INDUCTANCE DECREASE due to direct-current in coil is shown for ATE-0 and ATE-4 Adjustoroids.





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CIRCLE 15 ON READER-SERVICE CARD

Low-Noise Preamplifier Design

FIG. 1. BMEWS DUPLEXERS (foreground) are being tested in a resonant ring in the G. E. high power radar laboratory in Syracuse, N. Y. When the transmitter is radiating, the duplexers protect the receiver circuits by blanking off the receiver inputs; during the "listening" phase, the duplexers permit the extremely weak echo signals to enter the preamplifier. The high-speed scanning switch, housed in the tank in the background, must handle both multimegawatt output pulses and milli-micromicrowatt return signals.

RICHARD P. DEITZLER

Heavy Military Electronics Dept.
General Electric Co.

AS PROPELLER driven planes have evolved into the modern jet and the ballistic missile, so also the World War II radar has been improved to meet the needs of new tactical and strategic situations. Today, with peak power limits being approached, engineers are turning in other directions to increase radar system capabilities. One of the ways to achieve maximum system performance is through a careful design of the receiver preamplifier. Armed with a knowledge of overall system parameters and the expected performance, the designer now can choose from a variety of preamplifier possibilities.

The term *preamplifier* as used in this article will refer to that part of the active radar system which first receives the returned echo. Although crystal converters have a loss rather than a gain, they too, are included under the generic term of preamplifiers for the sake of consistency.

Radar Range Factors

From an examination of the basic radar equation (1) below, it can be seen that various factors; antenna gain, peak power, signal visibility, operating frequency and receiver sensitivity effect the overall range; consequently, the overall performance of the radar. Of these factors, the one most prominently influenced by the performance of the receiver preamplifier is the system noise figure, which defines the receiver sensitivity to weak or distant targets.

$$R_{max} = \left(\frac{P_t G_r^2 \lambda^2 \sigma}{(4\pi)^3 NF} \right)^{1/4} \qquad (1)$$

where R max = maximum range, Pt = peak power, Gr = antenna gain, λ = wave length of operating frequency, NF = noise figure, σ = visibility factor.

The limiting factor in weak signal detectability is usually system noise. This noise may originate from a number of different sources; external natural, man-made, and internal. External natural noise sources may be classified as cosmic noises, solar noises, lightning, background temperature and other natural phenomena. External man-made sources include ignition, other radars, and intentional jamming. Internal noise originates in the system itself. All of these can, at one time or another, contribute to a system's noisiness, hence, to its sensitivity.

System noise is at a minimum when the output noise is equal to the so-called Johnson noise, defined by the following equation:

$$P_n = KTB \qquad (2)$$

where Pn = noise power, K = Boltzman's constant, T = temperature (°K), and B = system noise bandwidth. This is the noise contributed by random electron movement within the input resistance.

Preamplifier Noise Figure

It is evident that a signal at maximum range is received by a radar system at an extremely low energy level. So low, in fact, that considerable amplification must be furnished by the system before the signal becomes usable. This need for amplification, or signal gain, often falls in the range between 100 to 120 db. Since the noise which occurs in the preamplifier is amplified with the signal, the signal-to-noise ratio established by the first stages ordinarily will continue unchanged to the receiver output, at least over a limited dynamic range. Hence, the preamplifier largely determines the final signal-to-noise ratio.

Referring again to the radar range equation, a 1-db reduction in noise figure corresponds to approximately a 7% increase in range; likewise, the same db increase in peak power will improve range performance by an equal amount. Today, however, it appears that some means other than an *ad infinitum* increase in peak power must be found to extend the range of military radars. Obviously a less expensive, although more sophisticated means of solving this problem is to improve the sensitivity of the receiver preamplifier. This approach is not an unmixed blessing since a reduction in system noise figure will also make the system more vulner-

able to unwanted external signals such as interference or jamming. The final choice then becomes an engineering compromise which must be determined by the particular application.

A radar system has an overall system noise figure, but each component also has its own noise figure. The relation of these components to the overall system noise figure is given by the equation:

$$F_T = F_1 + \frac{F_2 - 1}{G1} + \frac{F_3 - 1}{G1\,G2} \qquad (3)$$

F_T = overall system noise figure
F_1, F_2, F_3 = 1st, 2nd and 3rd components noise figures.
G_1, G_2 = 1st and 2nd components power gains

Because the denominator of each successive term is equation (3) grows larger, the contribution of later components to the overall noise figure can be neglected.

Other Preamplifier Criteria

Although the radar range equation stipulates that high sensitivity is a basic parameter, it is not the sole criterion of good preamplifier design. Other significant factors requiring consideration are: (1) Expected jamming environment, (2) the required dynamic range as established by target characteristics, (3) signal processing techniques used by the remainder of the system, and (4) system selectivity, which is related to (1).

The first named consideration, expected *jamming environment,* is so closely bounded by classified limits that lengthy discussion is impossible. However, receiver preamplifiers should, insofar as possible, enhance the signal to the detriment of any jamming.

Dynamic range, the second category for consideration in preamplifier design, is defined as the maximum possible increase in signal level above the lowest acceptable signal level without the creation of undesirable amplitude distortion. Achieving a maximum dynamic range is important since modern military radars are used to detect, locate and track fast-moving targets. In a typical system, target range can cause as much as 60 db change in received signal level.

In addition, the target itself does not present a continuously uniform reflection area. Hence, an additional factor is the target's instantaneous reflection aspect, which usually introduces an additional change of 20 to 30 db in signal strength.

Another factor which can influence dynamic range is the power handling capability of the preamplifier. Until recently preamplifiers of highest sensitivity have also been very sensitive to transmitter leakage. Consequently long term receiver sensitivity has been dependent on components which had to be protected from transmitter leakage by a TR tube or similar means. These devices are not entirely without loss and so can contribute to a reduction in receiver sensitivity. (Fig. 1).

Since the preamplifier usually precedes addition-

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DIRECTIONAL GYRO

This compact new gyro, designed for application in high-performance aircraft and missiles, provides extremely accurate attitude data. Its liquid bubble-type vertical sensing element generates error signals proportional to spin axis displacement from horizontal, while minor wiring modifications permit sensor connection to leveling torquer, completing inner axis leveling loop.

TYPICAL CHARACTERISTICS #A2215

Environmental Capabilities
Vibration: 5g, 20-1000 cps; 10g, 1000-2000 cps
Temperature Range (operative): —54°C to +71°C
(non-operative): —65°C to +85°C
Altitude: Unlimited

Azimuth Pickoff
Excitation: 26V, 400 cps, single phase
Output (sinusoidal): 11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor
Excitation: 115V, 400 cps, three phase
Speed: 23,500 RPM
Power: Starting: 35 watts Running: 7.5 watts

Performance Characteristics
Drift: 4°/hr. max.
Leveling Rate: Between 2° and 4°/min.
Azimuth Torquing Rate: 360°/min. (intermittent) 40°/min. (continuous)

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

VERTICAL GYRO

Kearfott's rugged new vertical gyro, designed for missile application, is a two-degree-of-freedom instrument with 360° of freedom about inner gimbal axis. Self-contained vertical erection system incorporates liquid bubble-type vertical sensing device.

TYPICAL CHARACTERISTICS #B2115

Environmental Capabilities
Vibration: 5 g, 20-1000 cps; 10 g, 1000-2000 cps
Temperature Range (operative): —54°C to +71°C
(non-operative): —65°C to +85°C
Altitude: Unlimited

Pickoffs
Excitation: 26V, 400 cps, single phase
Error from E.Z.: 10 min. max.
Output Voltage (line to line): 11.8V ± 5% max.

Motor
Excitation: 115V, 400 cps, three phase
Power: Starting: 35 watts Running: 7.5 watts

Performance Characteristics
Repeatability of Established Vertical: To within a cone of half angle equal to 12 minutes of arc
Scorsby Drift Rate in 5 Min. Time: 0.3°/min. (average)
Erection Rate: Normal: Between 2° and 4°/min. Fast: 80°/min. intermittent, 40°/min. continuous

Physical Features
Anisoelastic Drift: 0.08°/min/g² at resonance
Weight: 5.5 lbs. (approx.)
Mass Unbalance: 0.1°/min/g

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #Q2315

Environmental Capabilities
Temperature Range: (operative): —54°C to +71°C (non-operative): —65°C to +85°C
Altitude: Unlimited
Vibration: 10g, 10-2000cps

Pickoffs
Excitation: 26V, 400 cps, single phase
Output (sinusoidal): 11.8V ± 5% max.
Error from E.Z.: 10 min. max.

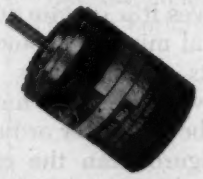
Motor
Excitation: 115V, 400 cps, three phase
Speed: 23,500 RPM
Momentum: 2.25 x 10^6 gm cm²/sec.

Caging and Preset Provision
(Electrically energized torquer type)
Excitation: 115V max./phase
Torquer Constant: 22.8 dyne cm/Volt²

Performance Characteristics
Free Drift: 5°/minute each axis
Runup Time: 1 minute max.
Torquing Rate: 360°/min. (intermittent) 40°/min. (continuous)

Write for complete data.

Synchronous Motor



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CIRCLE 16 ON READER-SERVICE CARD

al signal processing, it must function without modifying the signal so as to render it unacceptable to signal processing circuits. Typical types of signal processing to which the preamplifier must pass an undistorted signal are range tracking circuits, moving target indicator (MTI) circuits, etc.

As a criterion for preamplifier performance, the selectivity aspects must be determined with care. Most modern radar receivers make use of the superhetrodyne technique which applies both sum and difference inputs to the following intermediate frequency amplifier unless some attempt is made to avoid them. Until recently, many receivers were completely wide open and their image response almost as strong as that of the desired signal response. At present, however, various means of achieving selectivity are available. One way to achieve additional selectivity is by using a double conversion system. This means that the first intermediate frequency can be as high as 200 to 400 megacycles, and the second can be the popular 30 or 60 mcs. Under this condition, there is a wide frequency separation between the desired signal and the image; hence, the possibility of interference or jamming existing on the image frequency becomes much more remote (Fig. 2).

Cavity tuned pre-selectors and backward wave amplifiers, as well as proper circuit design in a balanced mixer, can be used to reduce the effects of unwanted signals. With these techniques the effects of spurious inputs can be greatly reduced. By combining a maximum dynamic range and very low response to spurious inputs, the preamplifier can be made receptive only to a particular transmitted signal while achieving maximum rejection of unwanted signals. However, if the preamplifier is capable of amplifying both signal and image noise with no preselection, the overall performance will be adversely affected. This situation may occur in a traveling wave tube preamplifier. Since the image noise can be as great as 3 db, the overall system performance is degraded by the same 3 db.

Current State of the Art

In recent years receiver preamplifiers have improved both in quality and in number of types. The system designer now has available a number of selections which can meet the demands of his particular system. Noise figures have been reduced substantially from the World War II figures of 12 to 15 db. It is not unusual now to find receiver noise figures of 2 to 4 db being achieved with the most modern circuitry.

Vacuum Tube Preamplifiers

World War II radars, in the main, employed pentode and triode tube amplifiers, or crystal converters to achieve maximum sensitivity.

Today's tube type preamplifier usually exists in the form of a triode grounded-grid stage. If the input circuit is properly designed, this first tube will determine the overall noise figure, providing, of course, that this tube has sufficient amplification to override any later noise contributions.

FIG. 2. INTERMEDIATE FREQUENCY Components of BMEWS surveillance radar system being tested by a technician at the G. E. high power radar laboratory, Heavy Military Electronics Department, Syracuse, N. Y.

The noise figure of the typical tube amplifier increases with increasing frequency so that few modern radars use tube preamplifiers beyond the UHF frequencies. For instance, in the L-band region the noise figure for this type of head becomes 9 to 10 db. Typical tubes which are used for this application are the GE 7077, the 6299 and the Western Electric 416 B. All of these tubes are co-planar triodes which have demonstrated their superiority as low noise performers. The grounded-grid triode configuration has the advantages of 1) wide band matching, 2) stability and 3) good low noise performance.

In the VHF region lumped-constant circuits are still possible, but as the designer proceeds above 400 megacycles, cavity type design comes into prominence and is used almost totally in the L-band region. A typical set of noise figure results that can be expected for tube preamplifiers operating over this range are shown in Fig. 1.

It should be noted that the selectivity curve of the plate-tuned triode preamplifier provides image rejection capability for the remaining portions of this type of receiver. This gives it a certain superiority over the untuned crystal mixers. Though the RF amplifier usually consists of one stage, or at most two, it must be followed by some form of crystal or tube mixer. The tube converter ordinarily has a much poorer noise figure than the crystal converter; therefore, a higher gain is required of the tube RF amplifier itself in order to offset this disadvantage. Typical RF amplifier tubes are capable of safely handling higher duplexer leakage powers than can crystals.

Crystal Converters

Through the use of a crystal converter as a preamplifier, the operational frequency of the receiver head-end has been extended into the millimeter region. Fortunately, since World War II the noise figures of all crystal converters have been greatly improved. The noise figure of the crystal mixer is primarily a function of its conversion loss, which is relatively independent of frequency. Using the best available crystals, it is possible to obtain a receiver with a system noise figure varying from as low as 6 db up to 14 db over this frequency range. A necessary part of such a preamplifier is its careful match to a low noise I-F cascode.

In order to avoid the degradation which will result if the microwave local oscillator signal used in the crystal converter contains excess noise, a balanced crystal arrangement is needed. This takes two forms, one of which is the "magic T" balanced mixer. The other is the short-slot coupler mixer. Both of these arrangements, by virtue of the electrical reversal of polarity in separate crystals, cause the cancellation of oscillator-injected noise in the input stages of the first I-F stage.

New Preamplifier Types

Insofar as sensitivity and noise figures are concerned, several improved receiver pre-amplifiers have been developed recently. These include the following: (1) Traveling wave tubes, (2) backward wave amplifiers, (3) parametric amplifiers, (4) masers, and (5) tunnel diodes.

Tunnel diodes are still in the laboratory stage. Initial performance indicates that this device probably will make important contributions to receiver preamplifier design within the next two years.

The *traveling wave tube* (TWT) makes use of a slow wave structure confined within a beam of electrons. The electron beam is initially formed by a series of electrostatic grids. In its traverse through the tube's structure it is confined within a narrow beam by means of a strong external magnetic field. Energy at the carrier frequency is coupled into this beam of electrons, and then coupled out again at a higher energy level. By proper use of high grade cathode material, and by minimizing losses from the electron beam to the helix and other grids, a low noise characteristic is possible.

Basically, the TWT is a very wide band device for which an operating bandwidth of an octave or more is not at all unusual. This latter characteristic implies that some form of filtering must be employed subsequent to this tube in order to avoid undesirable effects from image noise. A typical receiver using the traveling wave tube preamplifier probably would require double conversion, with the first intermediate frequency lying at least in the VHF range to permit use of the practical wide

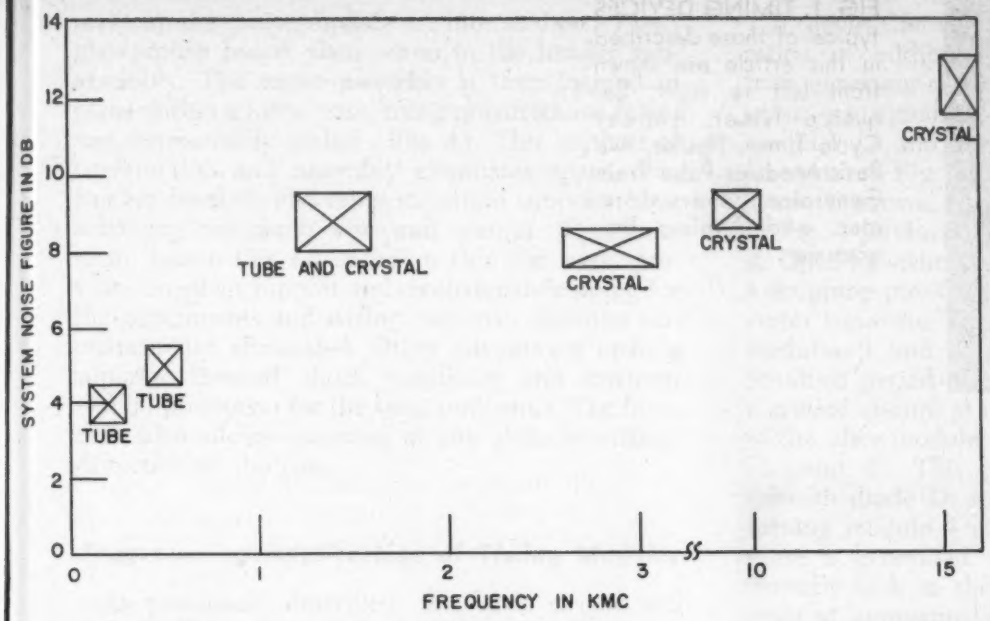


FIG. 3. TUBE and CRYSTAL PREAMPLIFIERS, Typical System Noise Figure Performance.

band structure either in S- or X-band. This approach permits the reduction of image noise to an unobjectionable level. The gain in this type of front end is ordinarily in excess of 20 up to 25 db. Although a 7 db system noise figure is obtainable in the S-band with this device, in the X-band system noise figure increases from 7 to 9½ db. The dynamic range of this device ordinarily is in excess of 80 db.

Another form of slow wave structure similar to the TWT is the *backward wave amplifier* (BWA) in which feedback is used to obtain amplification. As would be expected, this type of feedback tends to result in narrow band width. Bandwidths are usually less than 1 percent, although the gain obtained is comparable to the traveling wave tube. However, noise figures lower than that of the traveling wave tube have been obtained, at both S- and X-band frequencies. By means of special tuning circuitry a voltage-tuning capability across the entire operating band is possible. When this device is used, it is possible to obtain a rapidly tunable preamplifier which is instantaneously narrow band. Obviously, this has good interference rejection capabilities. In addition its dynamic range capability compares favorably with that of the ordinary TWT.

A third and very promising type of low noise preamplifier, the *parametric amplifier*, is currently enjoying great popularity. It derives its action and benefits from a variable reactance capability which is analogous to the variable resistance capability of ordinary diodes. By means of a high level local oscillator or "pump" the reactance, usually a capacitance, is varied in synchronism with the pump frequency. When a signal frequency is properly introduced into this circuit, energy from the pump is transferred to the signal frequency which appears amplified at the output. Bandwidths obtainable with this device vary from one-half to ten percent, depending on the type of circuitry used.

One of the more practical types of parametric amplifiers is the up-converter. With this technique a lower frequency is up-converted, usually to S- or X-band by mixing the lower frequency signal with the higher frequency pump energy. In addition to the up-converter, there are several other types of parametric amplifiers including the straight-through amplifier in which the output frequency is kept the same as the input frequency. This requires a form of regenerative amplification with which gains from 16 to 25 db have been realized over a very narrow frequency band. Another form of parametric amplifier is the down-converter. This is analogous to the common crystal converter. However, few positive results have so far been achieved with this device.

A final type of parametric amplifier is the traveling wave parametric amplifier. This type of amplifier is reasonably broad banded, with bandwidths up to 2 percent not unusual. The amplifier acts similar to an electron beam TWT. It depends for its action on a passive waveguide structure, permitting interaction with a pump source which is approximately twice signal frequency. All three of these parametric amplifiers are capable of very large dynamic ranges, between 80 and 100 db.

A less well known advantage of the parametric amplifier over former types of receiver preamplifiers appears to be its higher power capabilities. Experiments at General Electric have indicated that these devices are capable of handling CW power levels up to 10 watts with a peak power level of almost 100 watts. This is several orders of magnitude greater than is possible with either crystal or low-noise tube preamplifiers.

The *maser* is another very high sensitivity preamplifier which can have some special application where weight and flexibility are not primary design considerations. The maser amplifier differs from typical tube and crystal preamplifiers in two ways, (1) these amplifiiers make use of bound electrons rather than free electrons; and (2) they use rf energy rather than dc energy as a source for amplification. Magnetic moments of the electrons in the stimulated emission stage are the basis for the operation of the solid state maser.

Two principal types of masers have been reported in the literature. The first, a cavity type straight-through amplifier, is characterized by 1 percent bandwidths and very good dynamic ranges. Wider bandwidths up to 5 percent have been reported for the multiple cavity and multiple device masers, which make use of traveling wave action for its effects.

The maser, like the parametric amplifier in its simplified form, acts as a negative resistance. This means that in its elemental form it is a regenerative amplifier and, as such, has characteristics such that the square root of the power gain times the bandwidth is constant. The maser suffers from one main defect; in order to have maximum benefits from this type of operation it is necessary to operate the whole structure in an atmosphere of liquid helium. In addition, it requires a material that has appropriate energy levels when placed in the dc magnetic field and also is able to provide strong magnetic fields in the vicinity of the maser cavity. These characteristics might restrict use of the maser in radar systems.

Except for certain very simple and less expensive systems, it is probable that no new systems will be designed to employ either of the preamplifier techniques originally available at the end of World War II. In future radar systems, the operating frequency (Fig. 2) will probably determine the designer's final choice between the TWT family and the solid state family of preamplifiers.

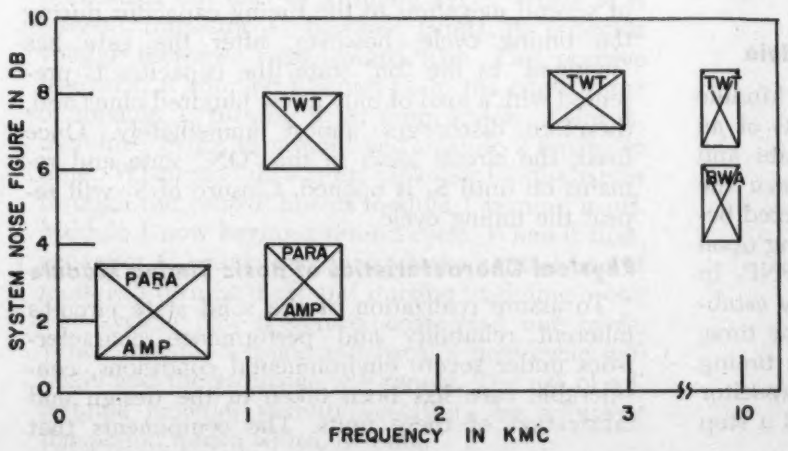


FIG. 4. PARAMETRIC, TWT and BWA PREAMPLIFIERS Typical System Noise Figure Performance.

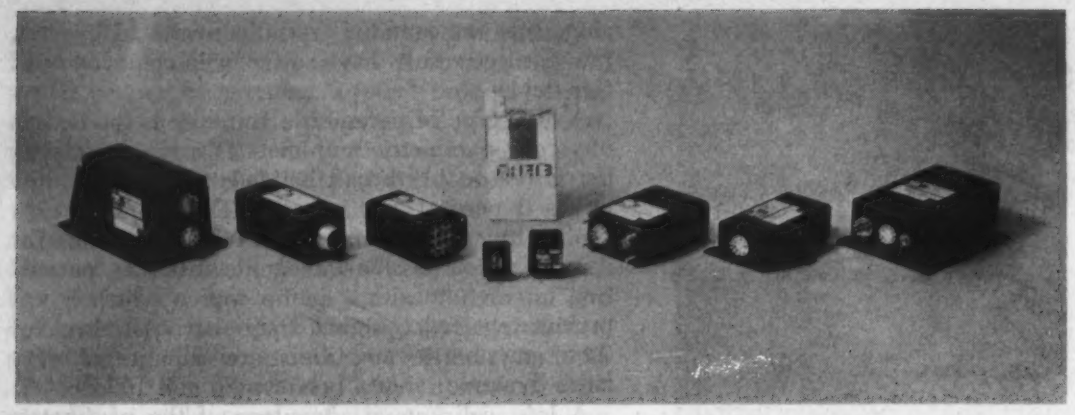


FIG. 1. TIMING DEVICES typical of those described in this article are shown from left to right; Sequence Timer, Repeat Cycle Timer, Flasher, two Basic Modules Pulse Train Generator, Intervalometer, and Timing Programmer.

"Building Block" Modules for Precision Timing and Control

HERBERT L. FISCHER, Tempo Instruments Inc.

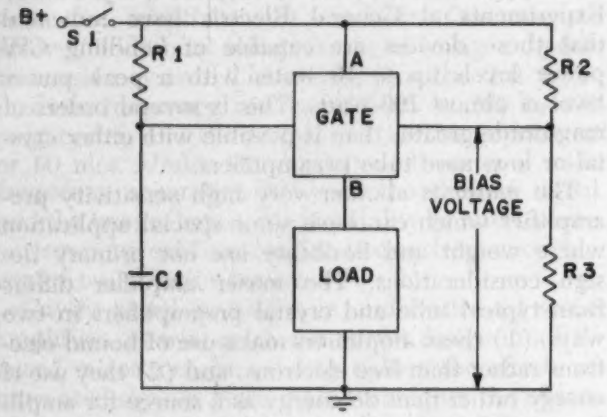


FIG. 2. (A) BASIC Timing Module, (B) Timing Diagram.

THE AUTHOR

Mr. Herbert L. Fischer, Senior Engineer, Tempo Instrument Inc., Hicksville, L. I., N. Y. has spent the last seven years in the field of transistor pulse and logic circuitry. Prior experience has been with Universal Transistor Products and Loral Electronics.

PULSE PROGRAMMERS are typical of the highly accurate devices required in increasing numbers to synchronize and sequence guided-missile flight and pre-flight functions. As the complexity of these functions increases, it becomes more and more evident that a basic building block, inherently versatile to permit its use in a wide variety of pulse program applications, is needed. The solid state timing module developed by Tempo, and employed by them in the design of various programmers and sequence timers (Fig. 1), is evidence of the sound engineering in this concept.

Operation of the Basic Timing Module

The operation of the Tempo Solid State Module is as follows: (Fig. 2) The module consists of an RC timing network, resistance divider, gate and load. The load is shown connected between the gate and ground. It can, however, be connected between the gate and supply voltage depending upon whether the output transistor is NPN or PNP. In Fig. 2, the closure of switch S_1 immediately establishes a bias on the gate circuit. At the same time, capacitor C_1 begins to charge through the timing resistor R_1. When the voltage across the capacitor reaches the bias voltage, the gate fires and a step voltage appears across the load. Fig. 3 is a schematic of the module with the load between the gate and supply voltage. In this case, upon firing, point A is driven to ground.

Before firing, the gate circuit exhibits a resistance of several megohms between points A and B. After the gate is triggered, this resistance drops to the order of from a few milliohms to several ohms. The action of the gate is extremely fast, completing the transistion from the "OFF" to the "ON" state in two microseconds max, and forcibly discharging the timing capacitor. The gate presents an impedance of several megohms to the timing capacitor during the timing cycle; however, after the gate has "snapped" to the "on" state, the capacitor is presented with a load of only a few hundred ohms and, therefore discharges almost immediately. Once fired, the circuit locks in the "ON" state and remains on until S_1 is opened. Closure of S_1 will repeat the timing cycle.

Physical Characteristics of Basic Timing Module

To assure realization of the solid state circuit's inherent reliability and performance characteristics under severe environmental conditions, considerable care has been taken in the design and fabrication of these units. The components that

make up the timing module are mounted on a fiberglass epoxy board, then wired to the header subassembly. The entire assembly is then foamed in place within a metal case, using polyurethane foam, and hermetically sealed (Fig. 4). This method of construction and assembly eliminates space consuming brackets and other structural supports, thus achieving minimum size and weight. The foam resin, which fills all spaces within the case, provides excellent support and mechanical damping for the components and wiring. Internal vibration resonances are eliminated. Other advantages include superior thermal shock resistance and environmental protection for the semiconductors. The foam resin also allows operation at any altitude without distortion of the case.

Programming Applications of Timing Modules

As previously described, the basic circuit will time in, fire and remain in the fired state. However, by bringing out certain control points other than those shown in Fig. 2, the standard timing module is capable of solving and meeting special requirements. The standard line of Solid State Timing Modules includes a "set—reset" control line, which provides the following logic: When a pulse of proper polarity, magnitude and duration is applied to the control line, the gate will trigger immediately. On the other hand, when a different pulse of proper polarity, magnitude and duration is applied to the control line, the circuit, if fired, will revert to its initial state. Upon expiration of this pulse, the circuit will begin its timing cycle again. By incorporating these added features, and the proper application of various logic blocks, an innumerable variety of programs and sequences can be achieved in order to satisfy various requirements. Following are typical design approaches which may be used in applying the Module to various system requirements:

A. Pulse Train Generator. Fig. 5 is a block diagram of a pulse train generator constructed with two timing modules. As shown, the ground closure produced by T_1 at the control line (terminal 6) of both modules, insures that each starts in the off state. In this condition, B+ appears at points A and B preventing the start of a timing cycle. When S_2 is opened, transistor T_1 becomes cutoff, its collector voltage therefore rises toward Ebb. This positive transition is coupled through C, to the control line of module 1, turning it on immediately. Point A, therefore, drops to ground and module 2 begins to time. When module 2 fires, capacitor C_3 discharges through the control line of module 1 turning it off. Module 1 now begins a timing cycle. When it fires, capacitor C_2 discharges through the control line of module 2 turning it off and starting its timing cycle. The system has, therefore, completed one cycle. When module 2 times and fires, a new cycle will begin and the sequence will repeat. The use of adjustable modules permits versatility by adjusting the period, pulse width, or both.

B. Multi-Channel Pulse Programmer. By incorporation of additional timing modules, the pulse train generator can be expanded to a multi-channel pulse programmer (Fig. 6). Here two timing modules (3 and 4) are driven by the pulse train generator of Fig. 5 to produce a predetermined program. As shown, application of power to the system in Fig. 4 produces a positive step at points A and B. Opening switch S_2 immediately turns on module 1 dropping point A to ground. By action of the inverter transistor T_1, operating power is supplied to modules 3 and 4. Upon expiration of a predetermined period of time, module 4 fires producing a ground closure at output 2. Module 3 is designed to fire after module 4, generating a ground closure at point D. This ground closure is transferred through diode D_1 to the control line of module 4 turning module 4 off. In this manner, a negative pulse is generated. Since the timing modules inherently lock in the fired state, point D will remain at approximately ground potential inhibiting module 4 from firing, although it may retime.

After a circuit has fired, application of a turn-off pulse will reset it and initiate a new timing cycle. The presence of a turn-off pulse has no effect on the timing cycle. However, if this pulse extends beyond the timing period, it will continue to hold the circuit off. Thereafter, upon removal of the turn-off pulse, the circuit will turn on immediately. The pulse at output 2 will, therefore, only be repeated after the ground closure at point A expires (recycling modules 3 and 4) and reappears.

To relate the foregoing operations to the output waveforms (Fig. 6B), S_2 opens at T = O. Operating power is immediately supplied to modules 3

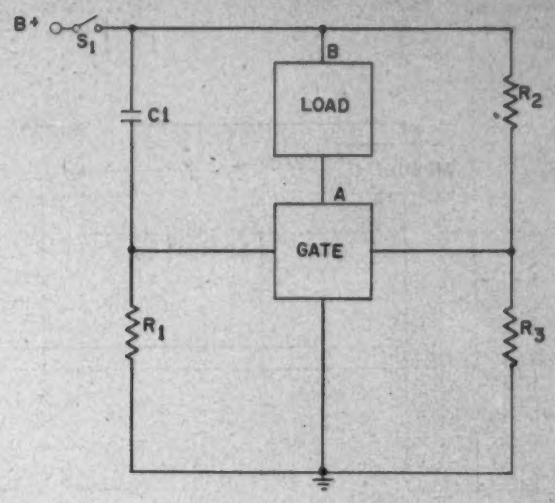


FIG. 3. BASIC TIMING MODULE with load between B+ and gate.

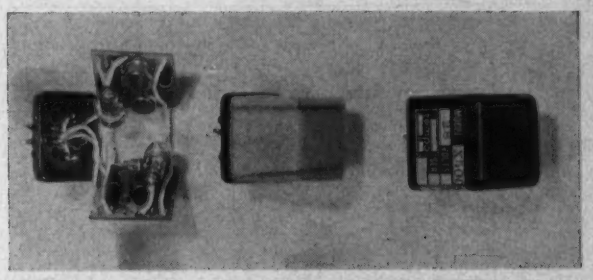


FIG. 4. MODULE CONSTRUCTION (left) Wired Terminal Boards and Header; (Center) Assembly Encapsulated in Polyurethane Foam; (right) Hermetically sealed unit.

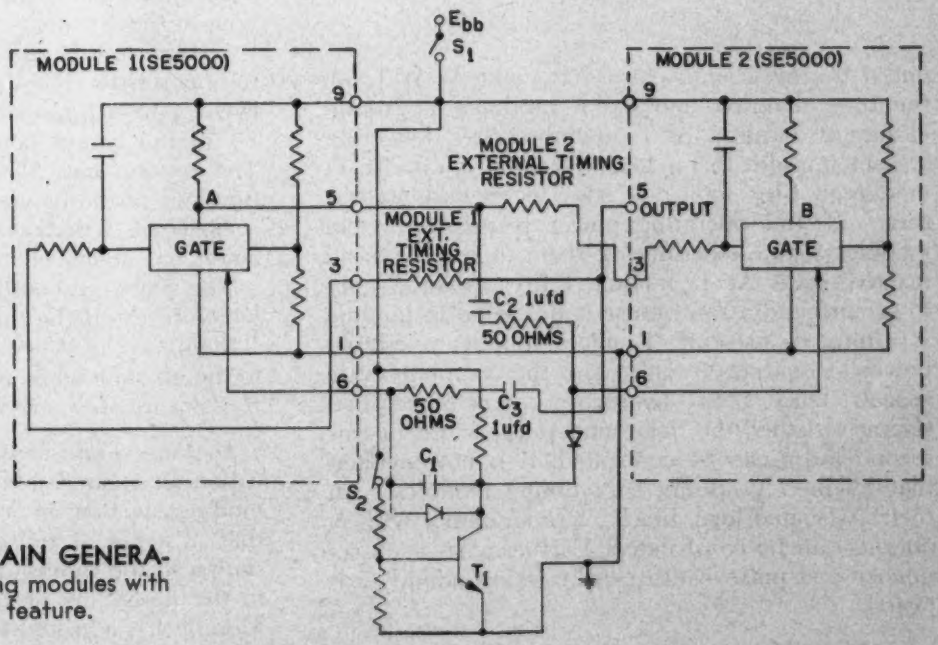


FIG. 5. PULSE TRAIN GENERATOR uses two timing modules with "set-reset" control feature.

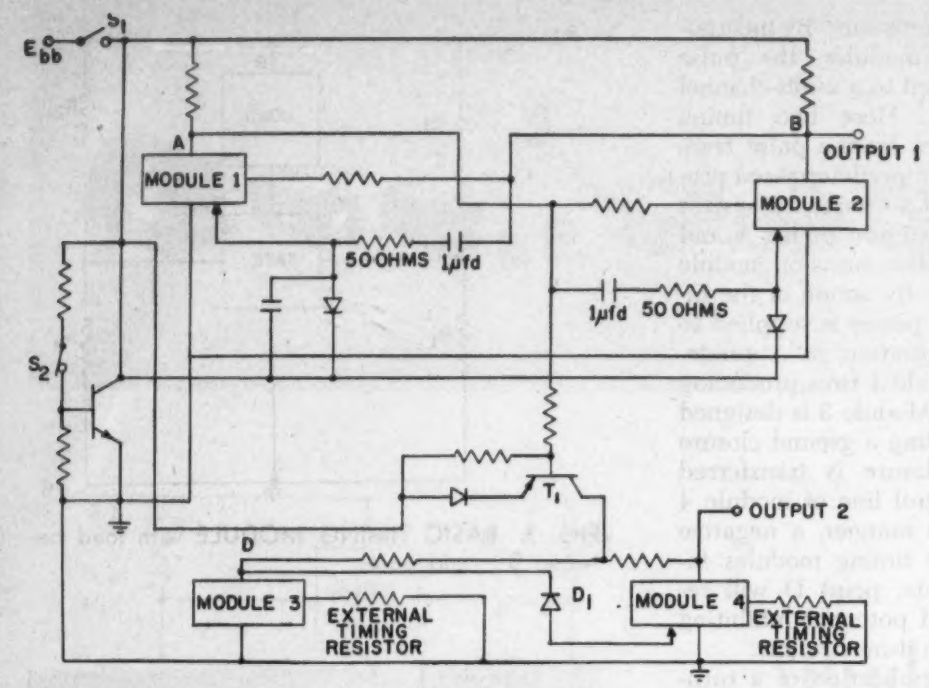
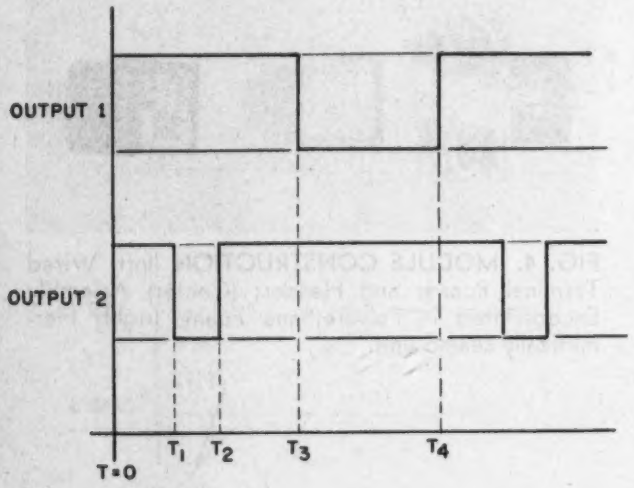


FIG. 6. (A) MULTI-CHANNEL PULSE PROGRAMMER uses three "set-reset" modules and one basic module. (B) Timing Diagram for Multi-Channel Pulse Programmer.



and 4 by the ground closure at point A. At T_1 on the time diagram, module 4 produces a ground closure at output 2. At T_2 module 3 fires delivering a reset impulse to module 4 turning it off. At T_3 module 2 fires; point B goes to ground, gate 1 turns off and operating power is removed from modules 3 and 4 permitting them to recycle to an inactive state. At T_4 module 1 fires, point A goes to ground and a reset pulse is delivered to module 2 turning its gate off; T_1 again supplies operating power to modules 3 and 4 and the complete cycle repeats. Once again, by incorporation of external timing resistors, the delay and pulse width of this second pulse can be controlled. It is now evident that by merely adding 2 N timing modules with their associated logic blocks, a programmer with N outputs can be constructed. Furthermore, each sequence and pulse width can be independently adjusted.

C. Free Running Ring Counter. By adding the proper diode logic an N stage free running ring counter can be constructed with N adjustable timing modules. Fig. 7 is a functional diagram of a count-of-four free running ring counter constructed with four modules. Upon closure of S_1 E_{bb} appears at the control line of gate "1" charging the "start" capacitor C. This charging current, flowing out of the control line turns gate 1 on. The counter is now in the 1 state.

Gate 2 now begins to time through the external timing resistor R_2. Upon completion of its timing cycle gate 2 turns on. E_{bb} is transferred through D_1 to the gate 1 control line turning gate 1 off. The counter has advanced to the number 2 position and gate 3 begins its timing cycle. When gate 3 turns on, Diode D_2 turns gate 2 off and the count has advanced to the third position.

The sequence continues through the fourth gate which turns off the third gate and initiates the gate 1 timing cycle. When S_1 is opened all gates return to the off state while capacitor C discharges through R_5. Closure of S_1 will begin the sequence again.

D. Pulse Train Sensor. Another interesting application that can be satisfied by the use of timing modules is that of a pulse train sensor. Assume that a string of pulses having the characteristics shown in the timing diagram (Fig. 6B) is applied to the input line of the block diagram of Fig. 8. Module 1 is adjusted for a time delay of $T_1 + \Delta t_1$ while module 2 is adjusted for a delay of $T_2 + \Delta t_2$. The operation of the circuit is such that as long

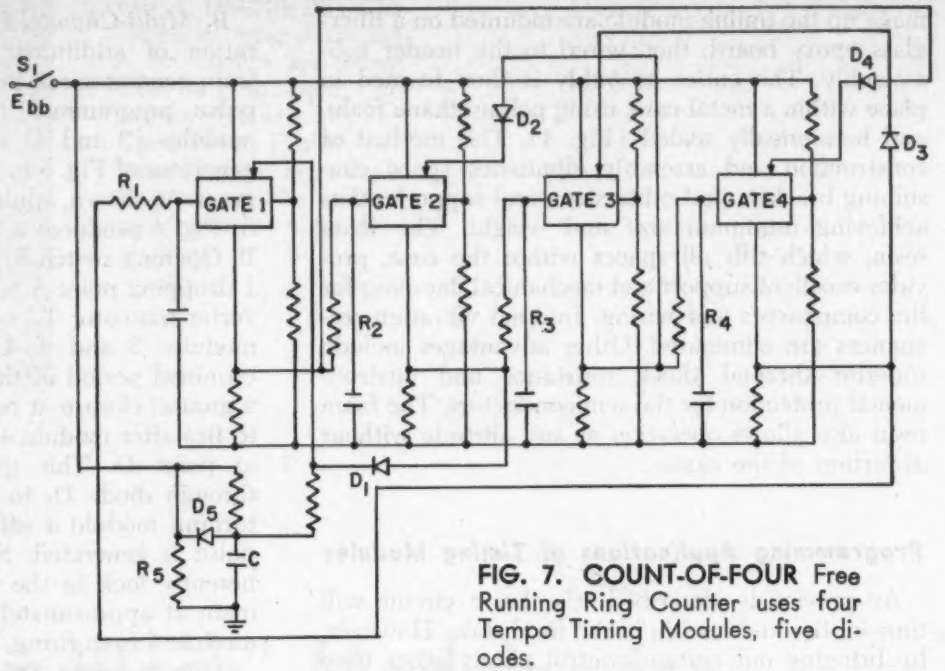


FIG. 7. COUNT-OF-FOUR Free Running Ring Counter uses four Tempo Timing Modules, five diodes.

as the pulses do not exceed the duration T_1 by Δt_1 or the time between pulses does not exceed $T_2 + \Delta t_2$ neither module will fire. If either of these input time functions increases by the associated quantity Δt_1 or Δt_2, the respective module will fire producing an impulse to the "or" gate which, in turn, drives the inhibitor circuit. The output of the inhibitor circuit prevents any further pulses from passing the "and" gate.

E. Driver Applications. Standard timing modules are capable of delivering 50 to 100 milliamperes depending upon the operating temperature extremes and output pulse polarity required. However, by using the module as a driver, any power output can be obtained. A repeat cycle timer is typical of the units that may be developed in this manner. Fig. 9 shows the timing diagram of such a unit, capable of delivering 250 mills at temperatures from —55°C to 125°C. Programmers and sequence timers, as described previously, can also be used in a like manner to drive power transistors, silicon controlled rectifiers or relay loads.

Conclusion

An ever-increasing demand for specialization continues to make itself evident, giving rise to various component manufacturers who limit their field of interest to a particular problem. Because of this specialization, the "State of the Art" in each of these particular fields has been able to advance more rapidly than if systems manufacturers were to attempt to become expert in each of the component problems encountered in system development. As the complexity of systems increases, so increases the need for standardization of components from the resistor to the "operational component" or

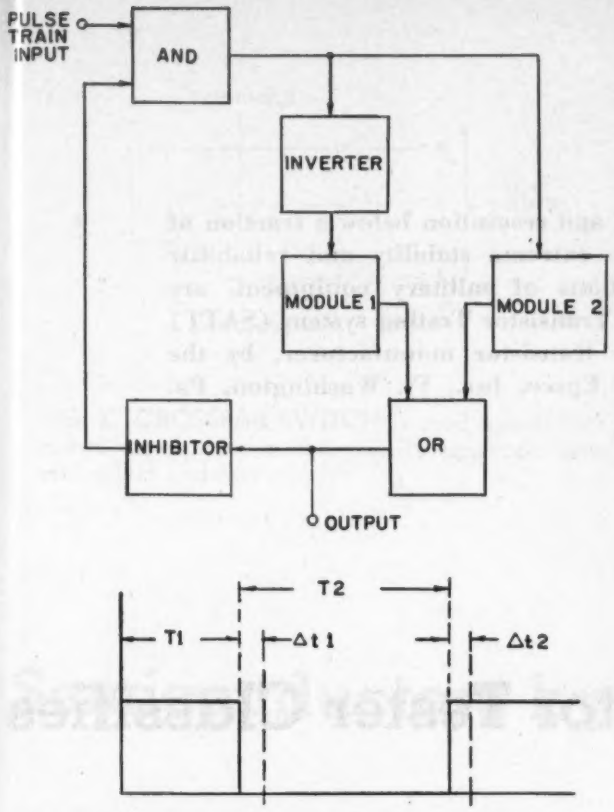


FIG. 8. PULSE TRAIN SENSOR block diagram. This device will monitor a train of impulses having the characteristics shown in the timing diagram. As long as the tolerances t_1 and t_2 are not exceeded the pulses are allowed to pass, but impulses which do not meet this pattern are cut off by the inhibitor.

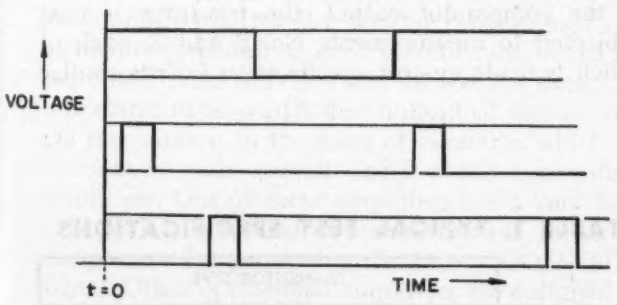


FIG. 9. TIMING DIAGRAM of Repeat Cycle Timer using a Tempo Timing Module as driver.

circuit. By using this "operational component" in the design of systems, in the same manner as resistors and capacitors are used in the design of circuits, the systems engineer can direct his creativeness and ingenuity to the full development of system concepts rather than circuits. In this manner, the Timing Module described, with its various control functions, can be applied to the solution of specialized problems in timing and programming functions for systems applications.

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FIG. 1. TRANSISTOR TESTER for Automatic or semi-automatic operation ripidly and accurately classifies bulk transistors against stringent customer and military specifications.

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Semi-Automatic Transistor Tester Classifies

TRANSISTOR PRODUCTION testing is essentially and primarily for the classification of the product in accordance with user specifications. When the product is destined for military applications, stringent Military Specifications become a part of, or determine the scope of these characteristics, and thus largely determine the quality of the product.

Because of the importance of the classification test, and because it must be repeated on each transistor unit, high reliability and accuracy in the testing system is essential. Unless automated, the cost of this test becomes a major item in the overall cost of each transistor.

The SATT system is semi-automatic in that the operator inserts each transistor in turn into a test fixture, starts the test, then deposits the tested transistor in the appropriate bin which is indicated by a light at the conclusion of the test sequence (Fig. 1). Bin indicator lights are installed in pairs to prevent malfunction due to the burnout of a single indicator lamp.

Mechanization of Measurements

The objective of the SATT transistor classification test is to differentiate a batch of transistors having more or less unknown parameters into five different types of transistors each having definite specifications. In the test sequence, each transistor is first tested against the test specification having the highest priority. Its qualification for lower priority types will be considered only if the specification for the highest priority is not met. On the other hand, a faulty transistor with excessive I_{CBO} will skip subsequent tests for other transistor types and will signal for immediate distribution to the REJECT bin.

The provision of early test termination for units meeting priority ONE or faulty I_{CBO} tests greatly shortens the test time for the batch as a whole. Since the test parameters may be changed at will, assigning different specifications to the various priority positions, the system is extremely flexible and adaptable to changing requirements. Analog computing techniques are employed in the tester and require that the transistor be connected to the individual test circuits in turn by a crossbar switching unit (Fig. 2). The three terminals of the transistor are connected to the test points of individual circuits designed by the letters B, C, and E, (corresponding to base, collector and emitter) in subsequent test circuit diagrams.

Typical test specifications for five different transistor types are shown in Table I. Each type undergoes four basic tests, two switching mode tests, with a seventh measurement optional. All the parameters for each transistor are determined by precision components wired into plug-in specification boards which may be inserted into the left-hand panel of the test console in any desired order of priority.

Analog techniques for measurement No. 1, V_1-I_{CBO}, are illustrated by Fig. 3. Supplies V_0 V_1*, and V_2 are controlled by setting resistors S_{01}, S_{11}*, and S_{21} respectively, which are mounted on the specification board. The supply V_2 provides the collector current with a clamping potential to V_1*. The asterisk (*) indicates that high accuracy is required for this parameter.

The base current through R_{b1} causes a voltage drop, which is measured in the comparator against the limit V_0. The comparator output is digitized to binary information, where it is interpreted as a GO/NO-GO condition. Following the interrogation of the comparator output, the transistor is next subjected to measurements No. 2 and 3, each of which is made against specification boards similar

TABLE 1. TYPICAL TEST SPECIFICATIONS

	TRANSISTOR TYPE				
MEASUREMENT	T-1	T-2	T-3	T-4	T-5
#1 V_I (V) I_{ebo} (ma)	10 | 15 10 | 50	10 | 15 10 | 50	10 | 15 10 | 50	1* | 20 | 12 1* | 50 | 5	10 | 15 5 | 50
#2 V_I (V) I_{ebo} (ma)	10 10	10 10	10 10	6 5	6 5
#3 V_{pt} (V)	7.5	6.5	6.5	16	6.5
#4 V_3 (V) I_c (ma) h_{fe}	3 0.5 >42	— — —	3 0.5 > 67	3 1.5 > 34	— — —
#5** I_b (ma) I_c (ma) V_e (mv)	1 8 <68	0.5 < 15.5 150	0.5 15 <148	5 50 <200	1 8 <100
#6** I_b (ma) I_c (ma) V_b (mv) V_c (mv)	— — — —	1 10 <445 —	— — — —	— — — —	5 50 — 200
#7* V_I (V) I_c (ma) h_{fe}	1 50 >22	1 50 > 22	— — —	0.5 50 > 44 < 175	0.5 50 > 44 < 140

Notes
* Optional
** Switching Mode

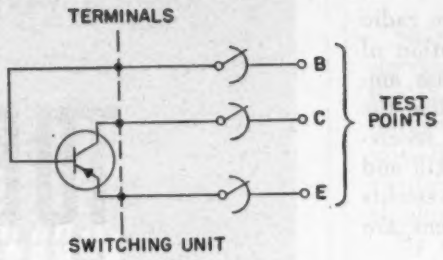

FIG. 2. **CROSSBAR SWITCH** is used to establish required connections in test priority sequence between test object and test circuits.

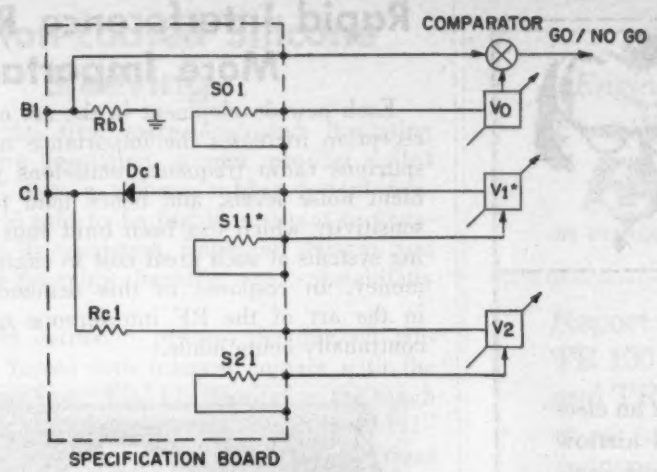

FIG. 3. **MEASUREMENT** No. 1, I_{CBO}

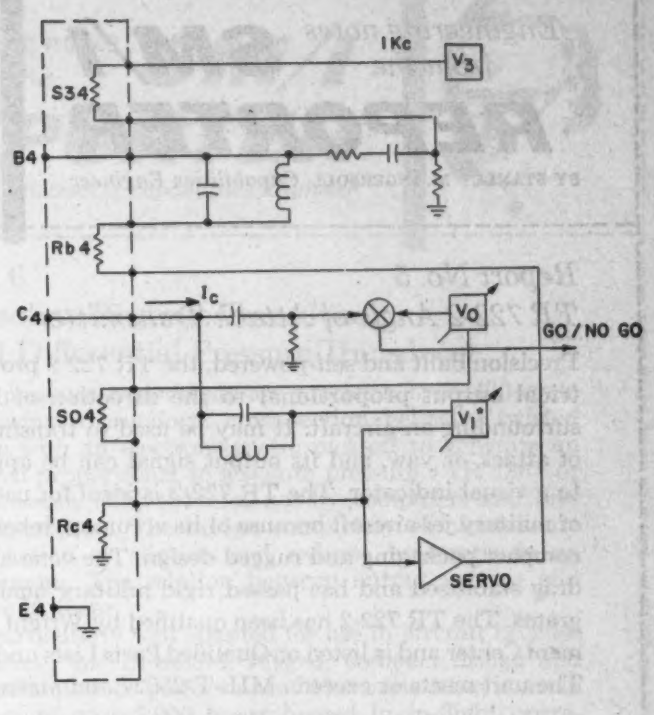

FIG. 4. **MEASUREMENT** No. 4, h_{fe} at 1 kc.

Semiconductors by Specifications

to that shown in Fig. 3.

The parameter h_{fe} at 1 kc is determined by the test circuit shown in Fig. 4. The programmed variables of the test circuit are provided on the specification board, while the signal generator, associated filters and the comparator with ac input are common. Similarly, the servo for automatic adjustment of the base current through R_{b4} is controlled by the programmed resistor R_{c4}. Similar programmed elements are provided on each specification board for switching mode tests 5, 6 and for test 7 if used.

Specifications panels and individual test circuits are mechanized in the form of networks which interconnect with special solid-state operational amplifiers. One of these amplifiers has a very high gain with a non-linear transfer function to act as comparator for generating the binary GO/NO-GO signal. Other operational amplifiers are designed as precision power supplies having high output capability, chopper stabilization for long term stability, and elimination of drift.

Each transistor type plug-in package has its type number engraved on the front panel. All circuit components within the plug-in package are passive and selected to MIL-Specs. Resistors are within 0.1% tolerance, as are all resistor combinations comprising a single resistance unit in the circuit.

Test Priority Flow

The test follows the Flow Diagram (Fig. 5). The classification into one of m different types T_i is performed in the priority order of $i = T_1, T_2, \ldots T_m$. Following the operator's START signal, the specification for type T_1 is automatically selected and the first test T_{ij} for Type T_1 is performed, corresponding to test T_{11}. Any NO-GO signal advances the control immediately to the next type T_{i+1}, providing that i is less than m. If $i = m$, then the test object is considered as "REJECT". A complete sequence of GO signals for a single type T_i will advance through all j tests for this particular type. As soon as $j = n$, the test object is considered "GOOD FOR TYPE T_i."

Automatic Features of System

The integrated system of the SATT equipment permits the use of pretests, built-in fault isolation and maintenance devices which would be excessive in fully modular units. Provisions are incorporated for self-checking of reference voltages, fuse alarm and manual stepping with direct readout of voltage settings. When in "manual" control, a push button advances the system in single steps through the whole sequence. Front panel indicators identify the order of the plug-in specification board and a direct instrument readout of all voltages makes possible an accurate check against known specifications.

For short production runs, and incoming inspection, the manual insertion of test objects is generally preferred by the user. In addition to manual insertion, however, the system is readily adaptable to fully mechanized operation with automatic feeder and sorter mechanisms, according to its developers. The engineering staff of Monitor Systems, Inc., will provide full cooperation in the adaptation of this system to special transfer and sorting mechanisms.

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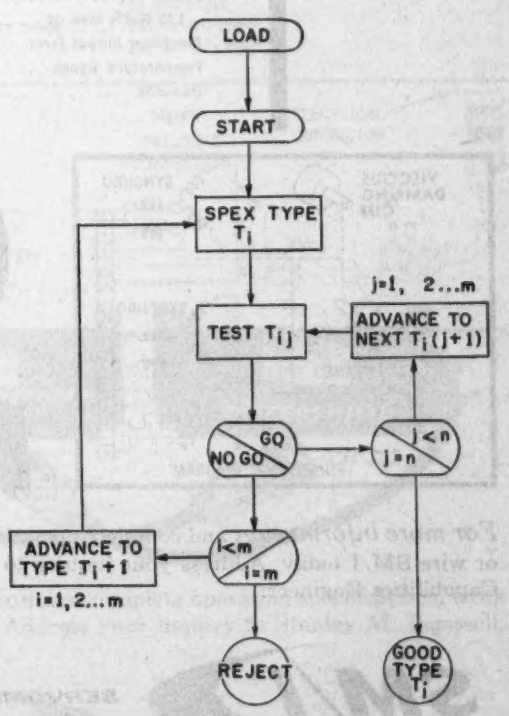


FIG. 5. **FLOW DIAGRAM.** Serial tests of m different type specifications (T_i) in priority order i.

Engineering notes from the **SM/I REPORTER**

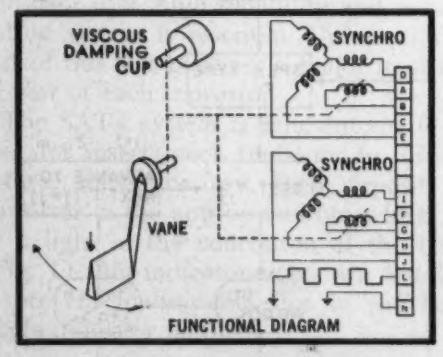
BY STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. 5
TR 722-2 Angle of Attack Transmitter

Precision built and self-powered, the TR 722-2 provides an electrical output proportional to the direction of local airflow surrounding an aircraft. It may be used to transmit local angle of attack or yaw, and its output signal can be applied directly to a visual indicator. The TR 722-2 is ideal for use on all types of military jet aircraft because of its accuracy, inherent stability, compact packaging and rugged design. The vane air foil used is drag stabilized and has passed rigid military qualification programs. The TR 722-2 has been qualified by Wright Air Development Center and is listed on Qualified Parts Lists under MS24378. The unit meets or exceeds MIL-T-25627 and amendments.

Typical Performance Specifications

Electrical Output	Two Synchro Transmitters
Electrical Angle	135°
Mechanical Angle	50°
Sensitivity:	
90 to 125 knots	0.2°
125 knots to Mach 4.37	0.1°
Power Requirements	115V at 400 Cycles
	26V at 400 Cycles
Heater	115V
135 Watts Max. at	30°C.
Electrical Output Error	±0.2°
Temperature Range	−54°C. to +93°C.
Damping	0.75 Critical at 110 knots
Weight	1.8 lbs. max.



TR 722-2 Angle of Attack Transmitter

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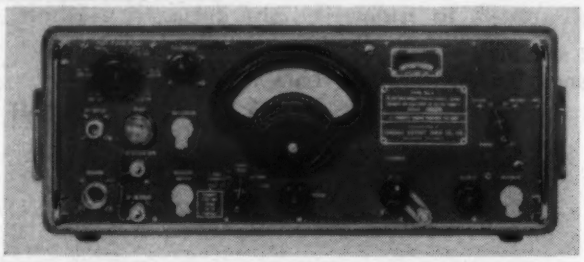
CIRCLE 32 ON READER-SERVICE CARD

Rapid Interference Reduction More Important

Each new development in the art of sensitive radio reception increases the importance of elimination of spurious radio frequency emissions which raise ambient noise levels, and hence tend to neutralize the sensitivity which has been built into the new receiving systems at such great cost in engineering skill and money. In response to this demand, improvements in the art of the RF interference measurement are continually being made.



NEW RADIO INTERFERENCE METER/RECEIVER speeds location and measurement of radio interference and verification of compatibility of modern weapons systems.

The new Stoddart Model NM-52A (AN/YRM-17) RFI meter (See Figure) is one of the latest with applications in radio interference measurement and location for military and commercial acceptance tests, frequency conversion and allocation studies, spectrum signatures, antenna propagation studies, field intensity surveys, RF energy surveillance and monitoring, and verification of the electronic compatibility of modern weapons systems. Such compatibility studies now include missile firing and guidance, computer, telemetering and communications; measurement of all associated or near-by rotating electrical devices, transmitting and receiving equipment and of any other system or equipment capable of producing unwanted radiated or conducted electrical disturbances.

The Model NM-52A comprises an ultra-sensitive UHF microvoltmeter and special purpose receiver developed to investigate, analyze, monitor and measure conducted energy or radiated electromagnetic energy within the frequency range of 375 to 1000 megacycles. Applicable MIL-Specs are exceeded by 20 to 40 db for sensitivity, and in suppression of oscillator radiation to a low of 8 micro-microwatts, which is 50 times better than specifications require. Other features include a new calibrated broadband antenna which facilitates rapid detection and measurement by eliminating frequent readjustment of a dipole antenna; single knob tuning; and an improved power supply with 0.5% regulation which can also double as a standard laboratory supply. A two-decade logarithmic meter scale increases the range of voltage measurements which can be accommodated with a single attenuator setting, and maintenance of a constant bandwidth over the entire frequency range improves the accuracy with which analyses can be made.

The new instrument is a development of the *Stoddart Aircraft Radio Co., 6644 Santa Monica Blvd., Hollywood 38, Calif.*

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Extrusion-coated Silicone Sleeving

Said to be the first extrusion-coated insulating sleeving for wire insulation, a new product called Ben-Har "1151" uses a silicone rubber formulation, durasyl, which is said to be highly resistant to abrasion. Because of its toughness, fingernail damage and similar product-assembly hazards are substantially eliminated.

By a patented extrusion process the durasyl silicone rubber is forced into integral contact with the braided fiberglass base (Fig. 1). Because of the tough elasticity of the extruded formula, Ben-Har "1151" readily expands to slip over irregular connections without damage to its insulating or coating qualities.

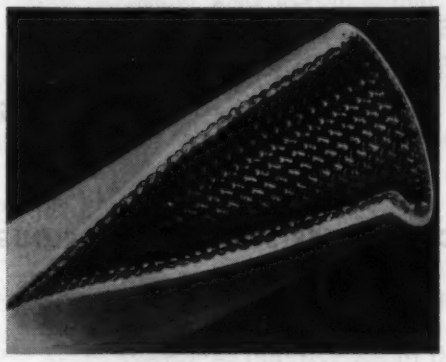


FIG. 1. **DURASYL SILICONE** rubber is extruded to form integral contact with braided fiberglass base of sleeving.

FIG. 2. **"BEN-HAR"** Extruded Sleeving (Sample in center), although more severely stressed than dip-coated fractured samples on ends of mandrel, recover shape after indefinite periods of distortion.

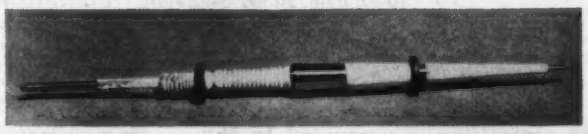


Fig. 2 illustrates the superior durability of the extrusion coated process using durasyl silicon rubber in comparison to dip coating with a conventional silicone rubber formula. Dip-coated sleeving is used on both right and left extremes of the mandrel, showing severe coating fracture caused by expansion or push-back. The sleeving shown between the two fibre washers is Ben-Har "1151", in which even more drastic stretching and push-back produces no fracture, and which recovers shape after indefinite periods of distortion.

The new sleeving meets MIL-I-18057A and NEMA Type 5 specifications. Rated for continuous operation to 220°C, it also has a low-temperature brittle point below —85°C. It is made in even-numbered AWG sizes 24 to 8 and all AWG sizes from 8 to 5/8". Dielectric strength of more than 600 v/mil is coupled with self-extinguishing burning properties and infinite resistance (48 hr megohm bridge test). Free production samples and data sheets are available from *Dept. P-3 Bentley-Harris Mfg. Co., Conshohocken, Pa.*

FOR THIS LITERATURE CIRCLE 112 ON READER-SERVICE CARD

Engineering notes from the **SM/I REPORTER**

BY STANLEY M. INGERSOLL, *Capabilities Engineer*

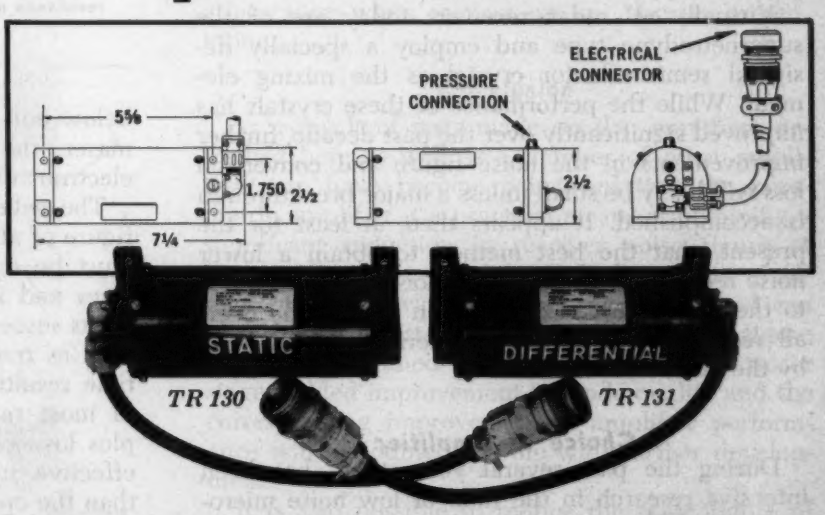
Report No. 6
TR 130 Absolute Pressure Transducer
and TR 131 Differential Pressure Transducer

These SM/I pressure transducers are precision built 400-cycle instruments using a cruciform cross-section helically twisted Bourdon tube with an electromagnetic pick-off to generate an electrical signal proportional to absolute pressure (TR 130) or differential pressure (TR 131) for use by computers and precision instrumentation. The design completely eliminates any mechanical friction or stiction and reduces hysteresis to an absolute minimum. The relation between output voltage and input pressure is linear.

They are particularly well adapted for use in aircraft because of high accuracy, low threshold, rugged, compact design and inherent repeatability of performance. The units have a mean time to failure of over 5,000 hours logged in in-flight operations. They meet the requirements of military specification MIL-E-5400.

Typical Performance Specifications

Scale Factor	0.0001487 volt/volt/mm Hg.
Applied pres. range	0 to 787 mm Hg. (absolute)
Damping (Restoration time)	0.1 second from full scale deflection to zero scale
Ambient temp. range	—65°F. to +175°F. (continuous duty)
Acceleration	Will withstand 30g without damage
Output voltage	0 volt to 3.50 volts for 30 volts of 400 cycles power applied and at load impedance of 20,000 ± 2% ohms
Frequency range	380 to 420 cps
Size	2½"x 2½"x 7¼"



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Parametric Amplifier Design in Radar Receivers

BRITTON T. VINCENT, JR.,
Texas Instruments Incorporated
Apparatus Division, Dallas, Texas

Introduction

FACTORS determining the range of a radar system are well known and the value of obtaining a low-noise receiver is appreciated by workers in the field, especially when the transmitter power and the antenna size are already at their practical upper limits.

Virtually all radar receivers today are of the superhetrodyne type and employ a specially designed semiconductor crystal as the mixing element. While the performance of these crystals has improved significantly over the past decade, further improvements in the noise figure and conversion loss will likely be small unless a major breakthrough is accomplished. It appears then, at least for the present, that the best method to obtain a lower noise receiver is to add a low noise amplifier prior to the mixer with sufficient gain so that the overall receiver noise figure is determined essentially by the low noise amplifier.

Choice of Amplifier

During the past several years there has been intensive research in the field of low noise microwave amplifiers. The most promising of these are the solid-state maser, diode parametric amplifier, electron beam parametric amplifier tube, backward wave amplifier and traveling wave tubes, and, recently, the tunnel diode. To obtain a significant improvement over crystal mixer receivers (noise figure of 6 to 9 db) we need an amplifier with a noise figure of say 4 db or less. At present to obtain this performance at X band frequencies and below our choice of amplifiers is narrowed to the maser, the diode parametric amplifier, and the electron tube parametric amplifier.

The solid-state maser exhibits the lowest noise figure of all known amplifiers. However, the maser must be operated at near liquid-helium temperatures and its use in radar systems is complicated by its susceptibility to over-load from strong signals such as transmitter leakage and the long recovery time resulting from such over-loads. Furthermore, in most radar systems, the antenna temperature plus losses in the duplexer and circulator gives an effective input temperature considerably greater than the operating temperature of the maser alone, so that the ultra-low noise of the maser cannot be fully utilized.

The diode parametric amplifier at present is capable of noise figures of less than 1 db at frequencies below 1 kmc to less than 4 db at X band. It has good recovery characteristics, adequate bandwidth for most applications, and is relatively simple and rugged.

The electron tube parametric amplifier has a higher noise figure than the diode amplifier, is considerably more complex, and in general offers no advantage over diode parametric amplifiers.

The diode parametric amplifier appears then to be the best choice for radar receivers at X band and below. We still have the choice of the "type" of parametric amplifier. This choice is between the: (1) up-converter, (2) the lower sideband up-converter, (3) the non-degenerate amplifier with equal output and input frequencies, and (4) the degenerate amplifier. The characteristics of each amplifier are briefly listed in Table I. From these characteristics we see that each form of parametric amplifier has some particular advantages that may make it the best choice for a given application. However, the "straight-through" negative resistance amplifiers (numbers three and four in Table I) appear to offer the best compromise of performance characteristics applicable to most radar systems.

Application Considerations

Before installing a low noise amplifier in a radar receiving system there are a number of factors

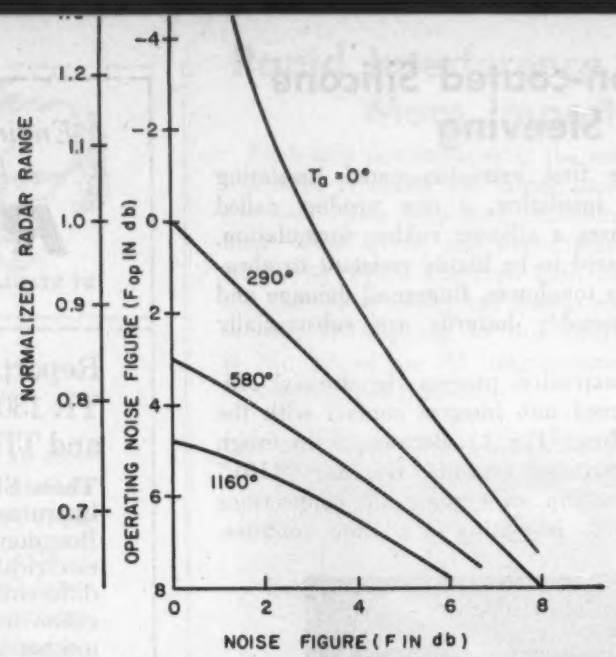


FIG. 1. NOISE FIGURE vs Operating Noise Figure and Noise Figure vs Normalized Radar Range for various values of Antenna Temperature in °K.

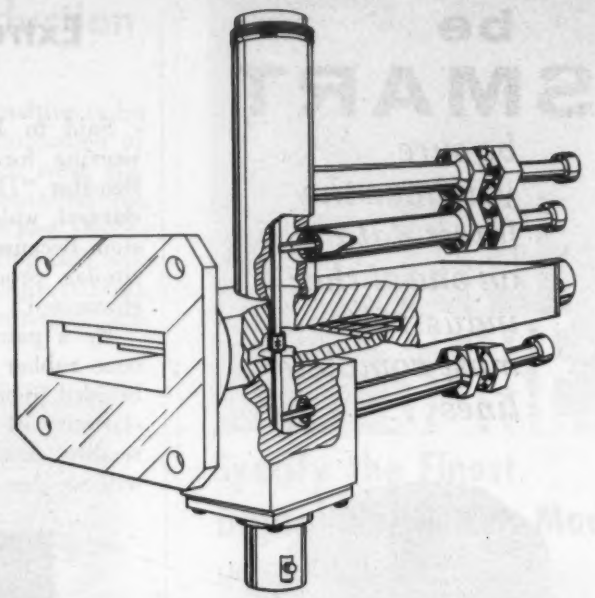


FIG. 2. S-BAND NON-DEGENERATE Parametric Amplifier, Sketch of Experimental Model XD-500.

TABLE I. TYPICAL CHARACTERISTICS FOR VARIOUS TYPES OF PARAMETRIC AMPLIFIERS

TYPE OF AMPLIFIER	TYPICAL PERFORMANCE	COMMENTS
1. Up-Converter	13 db gain, 20 mc bandwidth, 1 db noise figure at 400 mc input.	Unconditionally stable; gain limited to ratio of output to input frequencies restricting its practical use to approximately 1000 mc and below.
2. Up-Converting negative resistance amplifier	20 db gain, 35 mc bandwidth 2 db noise figure at 1000 mc input.	Not limited in gain, in general give improved gain bandwidth performance but at the sacrifice of noise figure. Output frequency is higher than input frequency.
3. Non-degenerate negative resistance amplifier	10-30 db gain, 3-25 mc bandwidth, 2-3 db noise figure at S band.	Can give good gain and bandwidth and lowest noise figure at a given frequency with a given diode.
4. Degenerate negative resistance amplifier	10 db gain, 50 mc bandwidth 6.2 db noise figure at X band.	Has the advantage of simplicity and ease tuning, easier to obtain larger gain-bandwidths than other amplifiers, suffers from noise and interference from idler channel.

which should be investigated other than just the noise figure of the amplifier. One of these factors is the location of the amplifier in the system. Here we meet two conflicting requirements. Assuming the possibility of an effective antenna temperature less than 290°K, we desire to locate the amplifier as near the antenna as possible in order to obtain an operating noise figure *lower* than the standard IRE noise figure for the receiving system. The operating noise figure, F_{op} is defined as:

$$F_{op} = (F-1) + \frac{t_a}{T_o} \qquad (1)$$

where t_a is the antenna temperature, F is the standard IRE receiver noise figure, and T_o is 290°K.

It is this noise figure that determines the sensitivity of the system. A curve showing F_{op} versus F for several values of effective input temperature is shown in Fig. 1. However, in the typical radar system which shares one antenna with the transmitter and receiver, it is not possible to locate the amplifier immediately adjacent to the antenna. Instead the amplifier must be located after the duplexer, or essentially just before the mixer stage. The effect of losses prior to the amplifier in plumbing, duplexer, T-R tubes, filters, etc. is to make the effective input temperature approach room temperature (290°K) as well as to lower the available signal power to the amplifier.

Other factors to consider are the amplifier recovery time to overload signals, its gain and phase stability, and, of course, the gain and bandwidth of the amplifier. The bandwidth must be at least adequate to pass the signal intelligence, and preferably larger in order to tolerate some error in tuning adjustments and tuning drifts. The primary requirement on gain is only that it be large enough to minimize sufficiently the noise contribution of the following stage.

Application of a Non-degenerate Parametric Amplifier to a S-band Radar

An experimental non-degenerate amplifier was incorporated in an ASR-4 S-band radar which Texas Instruments has developed and is now producing for the Federal Aviation Agency. This amplifier had a measured noise figure of approximately 2.5 db including the effects of the circulator used with the amplifier. It had a gain of 18 db with a bandwidth of 8 mc tuneable over a nominal range. A cross-sectional sketch of the amplifier is shown in Fig. 2, illustrating the varacter diode and tuning arrangements. The diode is a gallium-arsenide diffused-junction unit developed by the Semiconductor-Components Division of Texas Instruments. The tests were conducted in one channel of the ASR-4 which, at that time, had a receiver noise of 8 db. The amplifier gave an improvement in sensitivity of 5 db over the sensitivity of the radar without the amplifier.

The ASR-4 radar has an MTI mode which uses the pulse phase comparison scheme. If the amplifier produces phase jitter on the incoming signal, the result will be to lower the cancellation ratio and make returns from stationary targets appear as moving targets on the display. No quantitative measurements were made on phase jitter or cancellation ratio; however, careful observations of the radar display made while operating with and without the amplifier indicated very little degradation in MTI performance even with an unstabilized pump source.

The recovery of the amplifier to the transmitter leakage pulse was excellent, the recovery time of the receiver being entirely determined by the de-ionization time of the T-R tube.

Application of a Degenerate Parametric Amplifier

The degenerate amplifier is that mode of operation where the idler frequency is very nearly equal to the signal frequency and is terminated in the same load as the signal. The application of this type of amplifier to radar receivers is a matter of some controversy at present. First of all the theoretical minimum standard noise figure attainable is 3 db as determined by

$$F = 2 + \tfrac{1}{2}\left(\frac{1}{\gamma Q} + \frac{1}{(\gamma Q)^2}\right) \qquad (2)$$

γQ is the product of the capacitance change coefficient and the Q of the diode at operating frequency. The other factor of concern is the possibility of interference to the signal by the idler frequency. Both of these factors are real and can cause difficulties. However, depending upon the application, the amplifier can perform nearly, or equally, as well as the non-degenerate amplifier.

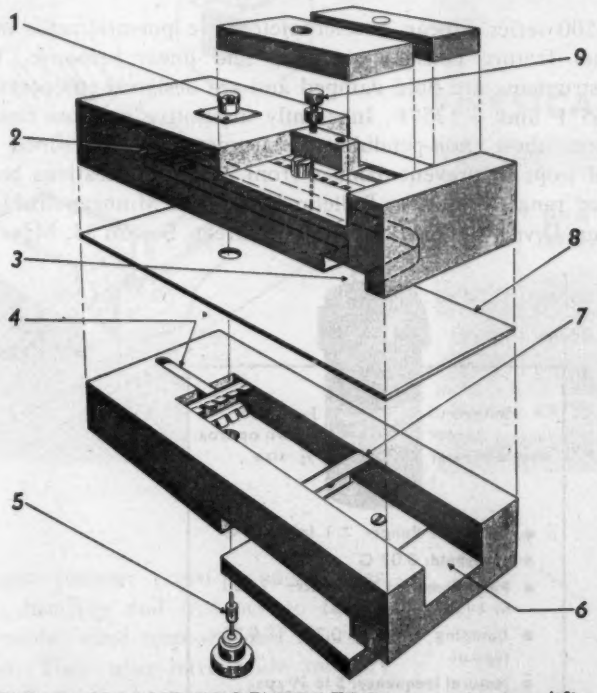


FIG. 3. X-BAND DEGENERATE Parametric Amplifier, Experimental Model, exploded view. Numbers identify the following parts: (1) Bias Connector, (2) Pump-tuning adjustable short, (3) Pump Input, (4) Pump-tuning adjustable short, (5) Varactor Diode, (6) Signal Port, (7) Signal-tuning Adjustable Iris, (8) Plate, (9) Pump-tuning Slide Screw Tuner.

For example, if the effective input is lower than 290°K then the theoretical minimum noise figure is less than 3 db, approaching 0 db as the input temperature approaches absolute zero.

In order to eliminate the possibility of idler interference, the signal spectrum may be limited to the bandwidth on one side of half the pump frequency. This is sometimes referred to as quasi-degenerate operation. In a large number of radar applications, it is not necessary to separate the idler from the signal. The effect of overlapping signal and idler spectrum in a non-coherent pulse radar, for instance, is to modulate the pulse envelope by the beat frequencies between the signal and idler spectrums. In fact it has been shown that in an MTI radar which uses a synchronous detector, the degenerate amplifier causes no deterioration of performance over that of a non-degenerate amplifier if the pump frequency is properly related to the transmitting frequency. In other words, for this application the effective noise figure of the amplifier is 3 db less than its IRE standard noise figure.

An experimental X-band amplifier using gallium arsenide diodes was installed and tested in the APS-80 ASW radar. This amplifier had a gain of 20 db with 3 mc bandwidth and a noise figure of 6 db. The relatively high noise figure is attributed to high input coupling loss and the improvement in overall receiver sensitivity was only a modest 2 db. Fig. 3 shows an exploded view of the amplifier.

The effect of having the signal and idle responses of the amplifier overlapping gave the predicted result of modulating the detected pulse envelope by the more or less random beat frequencies between the signal and idle spectrums. It also gave a very similar result on the output noise, giving the appearance at least of increasing the low frequency noise components. This gave the noise a "coarse" appearance when viewed on an A-scope presentation.

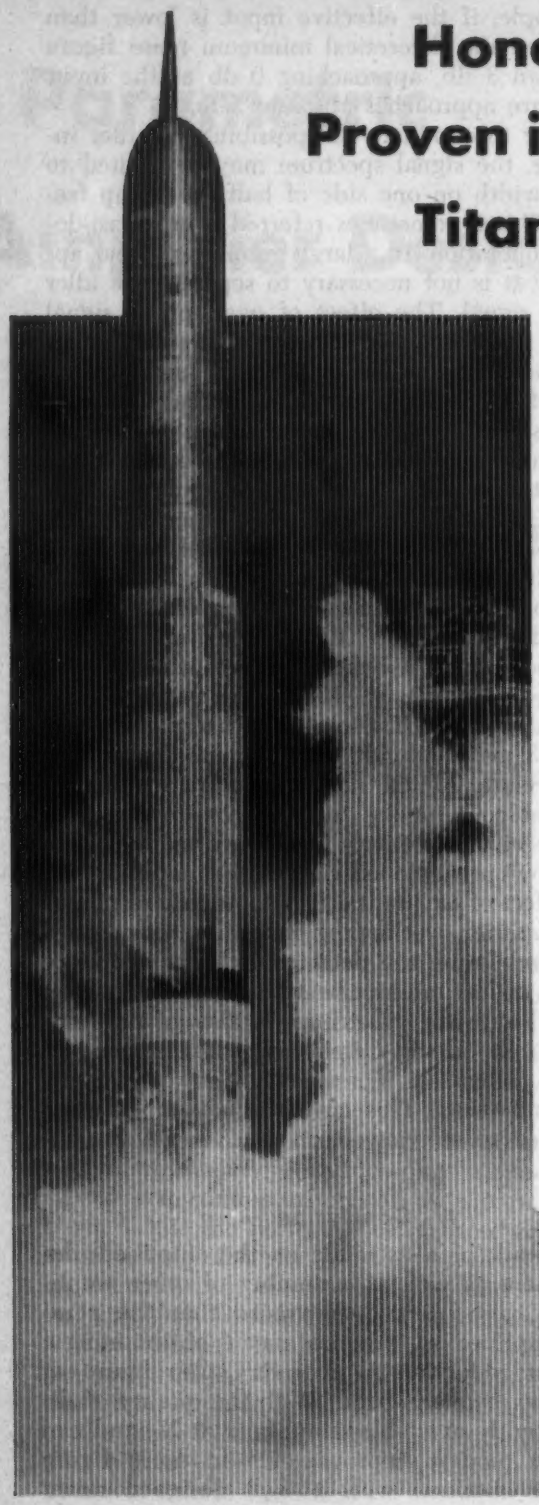
Conclusion

As a result of tests made on the amplifiers described here as well as a number of other amplifiers, we have become convinced that the parametric amplifier is a practical means of obtaining a significant reduction in receiver noise figure at frequencies below X-band. With the quality of diodes presently available, amplifiers at X-band can give only modest improvements in noise figure over that obtained with a well designed mixer stage. Added improvement in diode quality and the corresponding improvement in amplifier performance will undoubtedly come with further development.

It is also possible to reduce the noise figure of an amplifier considerably by cooling the diode, provided the diode package is designed properly and the semiconductor material used does not change properties while cooling. Gallium arsenide is excellent in this respect. Tests made at Texas Instruments and other laboratories have indeed verified this reduction of thermal noise when cooled to near liquid nitrogen temperature.

FOR MORE INFORMATION CIRCLE 100 ON READER-SERVICE CARD

Honeywell Accelerometers Proven in Air Force Minuteman and Titan Tests



Honeywell accelerometers undergo a saw-tooth shock force of 100 G's for six milliseconds during test at the Environmental Test Laboratory of Avco's Research and Advanced Development Division.

Honeywell Linear Accelerometers, Model 515, were selected by Avco for the flight test instrumentation system of the Air Force TITAN and MINUTEMAN ICBM re-entry vehicles. The Avco Test Program included shock, random vibration, simulated transportation vibration, acoustic noise, standard acceleration, peak longitudinal and lateral acceleration, and high and low temperature tests. "Honeywell's Linear Accelerometers endured our Flight Proof Test Program without structural failure and were given our Flight Proof Test Certification" stated Mr. Paul Myslicki of Avco's Environmental Test Laboratory.

Type LA-500 series Linear Accelerometers are potentiometer output devices that feature constant damping and linear response. These reliable instruments are fluid damped and are designed to operate between −65°F and +175°F. Inherently insensitive to cross coupling accelerations, these non-pendulous instruments are provided with mechanical stops to prevent damage from input accelerations beyond the specified range. Write for Bulletin LA-500 to Minneapolis-Honeywell, Boston Division, Dept. 55, 40 Life Street, Boston 35, Mass.

Honeywell Linear Accelerometer — Type 500, shown approx. ⅓ size

- **Full Scale Range:** ±1 to ±60 G
- **Threshold:** 0.02 G
- **Potentiometer Resistance:** 1,000 to 14,000 ohms
- **Damping Ratio:** 0.75 ±0.35 typical
- **Natural Frequency:** 5 to 19 cps
- **Cross-axis Sensitivity:** ½% of full scale
- **Shock:** to 50 G
- **Vibration:** MIL-E-5272
- **Size:** 1 7/16" diameter, 3¼" long
- **Weight:** 1 lb.

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Military Products Group — SINCE 1885

CIRCLE 19 ON READER-SERVICE CARD

Missile Support Cabinets Feature Air-Transportability

Cabinets and consoles for electronic and fire control equipment are important elements of support equipment in every missile system and radar system. In such ground and ship based systems the question of weight might seem to be secondary. However, mobility of a high order, extending to air-transportability either by transport carrier planes or by helicopter, is now considered an essential of all support equipment for modern Army, Air Force and Navy.

Strength, precision fit and system compatibility need not be sacrificed to attain the necessary lightness. For many years, Brooks & Perkins, Inc., 1950 West Fort St., Detroit 16, Mich., has specialized in cabinets for Nike and other missile systems (Fig. 1) arc-welded from aluminum and magnesium. Special techniques to prevent distortion during welding and to relieve post-welding stresses have been developed.

Cabinet requirements vary from very close toler-

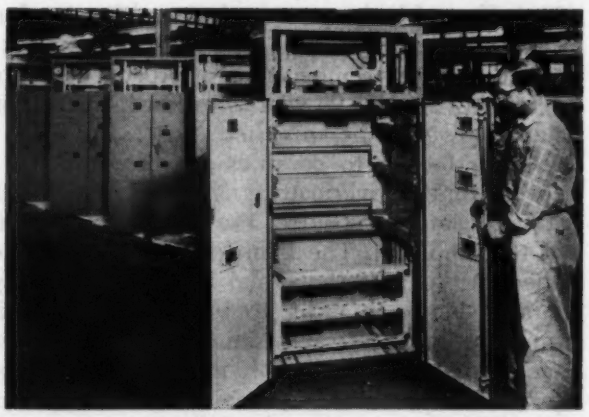

FIG. 1. ARC-WELDED Magnesium cabinets for NIKE-HERCULES System weighing 223.5 lbs. are equivalent in stiffness and strength to steel cabinet weighing about 525 lbs.

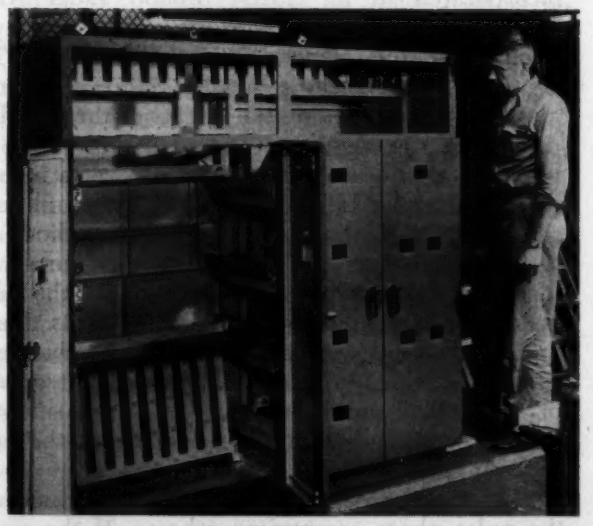

FIG. 2. TERRIER MISSILE System cabinet made for Western Electric is typical of larger precision cabinets made by Brooks & Perkins, Inc., for mobile missile support systems.

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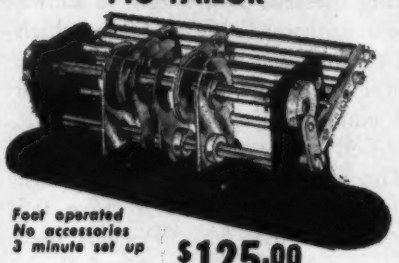

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CIRCLE 20 ON READER-SERVICE CARD

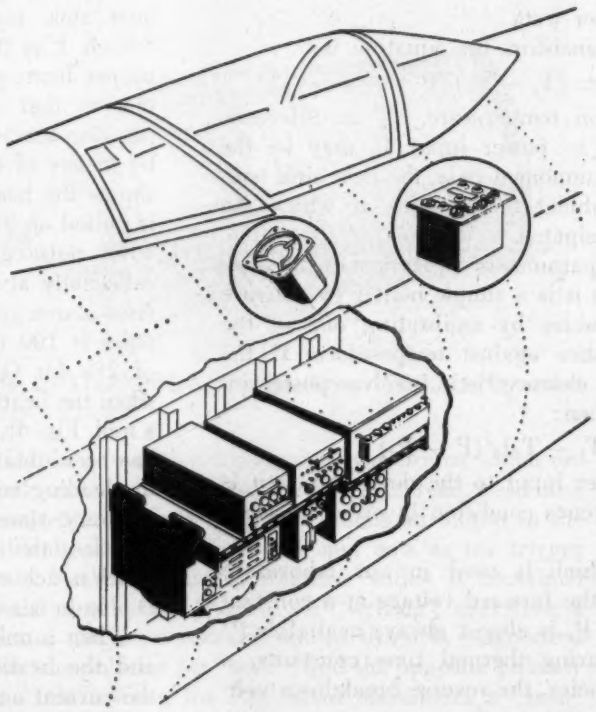
ances and ultra-fine finish appearance to relatively crude racks where utility and low price are most important. For electronics firms and missile systems managers, lightweight cabinets to mount and house equipment can be built from specifications only. Fig. 2 shows a typical large magnesium cabinet made for Western Electric for use in the Terrier Missile system.

Cabinets can be 100% custom built with specially designed extrusions and hardware, or may be custom assembled from standard parts to fit the customer's requirements. Electronic engineers need never redesign the basic equipment to fit off-the-shelf enclosures. In every case light weight combined with strength and precision fit characterize Brooks and Perkins cabinets.

FOR MORE INFORMATION CIRCLE 101 ON READER-SERVICE CARD

Air Navigation System is Multifunction Marvel

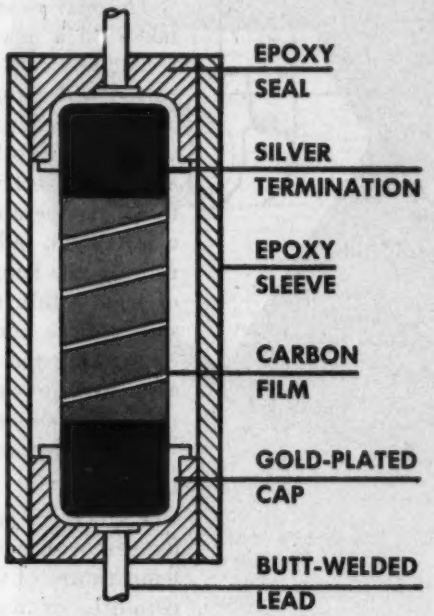
New self-contained navigation system AN/APN-131, here shown installed in a Republic F-105D is one of a family of LFE navigation systems suitable for fighters or helocopters flying from low to ultrasonic speeds.



These systems supply present position coordinates, groundspeed, track, heading and distance to target, wind vector components, wind memory and alternate destination selection. They also have wide military and commercial implications because of their independence from ground navigational installations. Built by the Laboratory for Electronics, Inc., 1079 Commonwealth, Boston, Mass., it is notable for its small weight-space requirements, of only 210 lbs and less than 7 cubic feet.

FOR MORE INFORMATION CIRCLE 102 ON READER-SERVICE CARD

NEW MEDIUM PRICED LIGHT WEIGHT CARBON FILM RESISTORS



NEW DESIGN

This new design enables Mepco to offer a moderate cost, dependable, lightweight carbon film resistor that has new features to meet the environments required by Military Specification MIL-R-10509C Characteristic B.

FEATURES

Moisture which might be absorbed during extended storage periods under high humidity conditions, cannot be transmitted to the carbon film due to the dry air space between the epoxy tube and the resistive element.

PHYSICAL AND ELECTRICAL CHARACTERISTICS

TYPE		RATING			VOLTAGE RESISTANCE			SIZE			
Mepco	MIL-R 10509C	Watts Mepco @ 125°C	Watts Mepco @ 70°C	Watts MIL @ 70°C	Max. Cont. VDC	Min. Ohms	Max. Meg. Ohms	Length	Tol.	Dia.	Tol.
EP-012	RN60B	0.125	0.25	0.125	250	5	1	.4335	±.0035	.156	±.010
EP-025	RN65B	0.25	0.50	0.25	300	10	2	.640	±.015	.240	±.010
EP-050	RN70B	0.50	1.00	0.50	350	10	5	.830	±.015	.240	±.010
EP-100	RN75B	1.00	1.00	1.00	500	10	10	1.093	±.020	.395	±.010
EP-200	RN80B	2.00	2.00	2.00	750	50	20	2.230	±.020	.395	±.010

EP SERIES

MEPCO INC.

CIRCLE 21 ON READER-SERVICE CARD

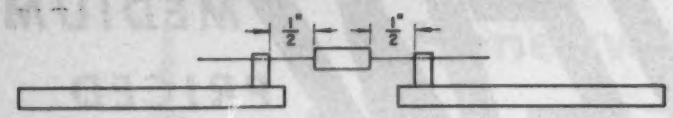


FIG. 1. **STANDARD** Mounting for Lead Mounted Diodes.

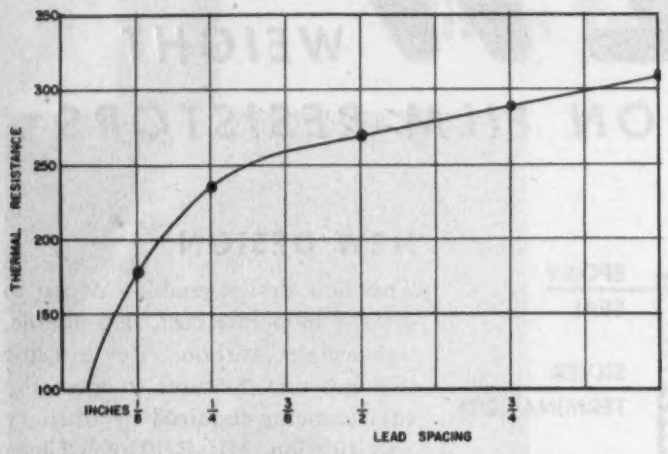


FIG. 2. **THERMAL** Resistance Curve.

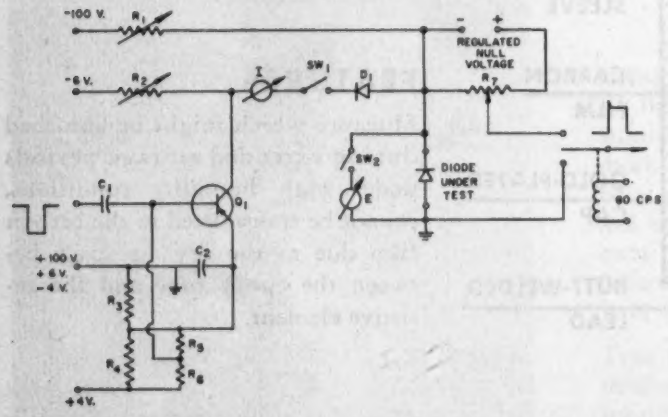
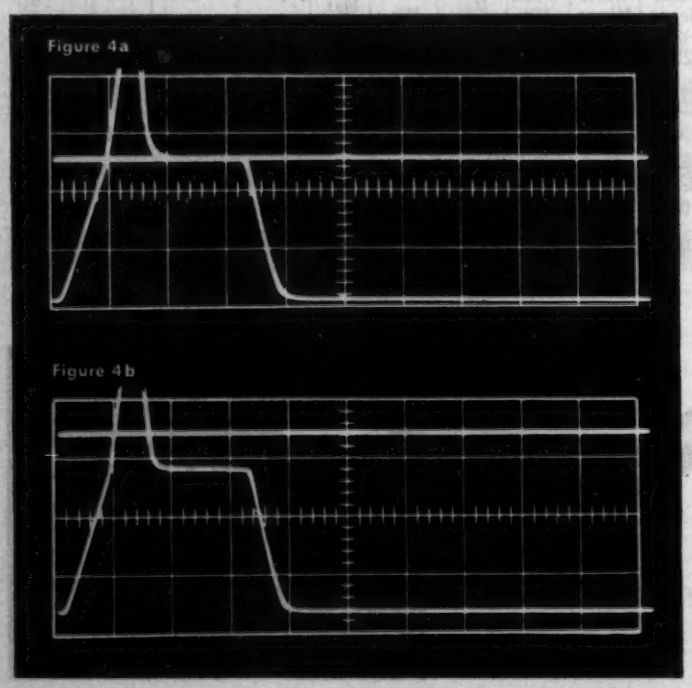


FIG. 3. **THERMAL** Resistance Measurement Circuit.

FIG. 4. **DIODE** performance (a) with heating current less than null value; (b) at null value.



Thermal Resistance Measurements

LEONARD J. ROSE, Measurements Engineer, Semiconductor Div., Hoffman Electronics Corporation

Thermal resistance, while not a new concept, has taken on a new importance with the introduction in recent years of semiconductor devices which have received widespread acceptance chiefly because of their ability to control or dissipate high power in small volumes. Unfortunately, diodes and transistors, like all other electrical components, have maximum internal temperatures which, when exceeded, produce catastrophic failure. Thermal resistance is simply the ratio of the temperature rise to the rate of generation of heat within the device under consideration under steady state conditions. Since the heat is generated electrically, the rate of heat generation is most easily expressed in watts and the thermal resistance Θ, in centigrade degrees per watt.

For diodes and transistors the equation is:

$$\Theta = (T_j - T_x)/P$$

where T_j = junction temperature, T_x = reference temperature, and P = power input T_x may be the temperature of the component case, the heat sink temperature, or the ambient temperature at which the energy is finally dissipated.

Since most of the parameters of semiconductors are temperature sensitive it is a simple matter to measure the junction temperature by calibrating one of the electrical characteristics against temperature. If the measurement of this characteristic involves power input to the device, then:

$$\Theta = (T_j - T_x)/(P - P_r)$$

where P_r is the power input to the device when it is switched to the reference condition in order to measure T_j.

The parameter which is used in our laboratory for measuring T_j is the forward voltage at a constant current. In this case P_r is almost always negligible.[1] However, for measuring thermal time constants, a more sensitive parameter, the reverse breakdown voltage at constant current is used.

As emphasized in reference (1), the mounting of the device whose thermal resistance is to be measured, has a large effect on the result. For components such as glass diodes and top-hats which are mounted by their leads, we have adopted the following standard condition for our measurements.

As shown in Fig. 1, the diode is clipped into Cambridge Thermonic spring clips mounted on large heat sinks with the distance between the body of the diode and the inside of the spring clip maintained at one-half inch. Heat sinks and diode are shielded from drafts.

The effect of varying the free lead length is shown in Fig. 2 for a "600 milliwatt" glass diode which has been the subject of considerable discussion in the industry. A similar variation which can be measured is found for all lead mounted diodes.

Fig. 3 is a simplified schematic diagram of the measuring circuit. The reference current is adjusted by means of R_1 at room temperature to give 0.5 volt across the device under test. The device is then immersed in a high temperature oil bath and R_7 is adjusted to give a null on the oscilloscope, whose input is switched between R_7 and ground by a mercury relay driven at 60 cycles.

The device under test is then mounted on a suitable heat sink maintained at the desired temperature. Switch 1 is turned on and R_2 is varied to give the proper heating current to raise the junction temperature to that of the high temperature oil bath. The junction temperature is sampled at the rate of 200 cps by means of the transistor-diode switch Q_1-D_1 which shunts the heating current through Q_1 when the base is pulsed on by a negative going pulse from a DuMont 404R pulse generator. The emitter of Q_1 is raised sufficiently above ground so that the collector voltage rises above ground and D_1 is switched off. The input pulse is 100 micro-seconds long, giving a duty cycle of 2% for Q_1. Fig. 4a shows the oscilloscope trace when the heating current is less than that required for a null. Fig. 4b shows the oscilloscope trace when a null has been obtained. The recovery of D_1 can be seen at the leading edge of the pulse. D_1 is selected for fast recovery time and low reverse leakage current. In practice, the oscilloscope sensitivity is increased in order to achieve a more exact null. A Tektronix 53/54 D plug-in is used for this purpose.

When a null has been achieved, SW2 is thrown on and the heating power is determined by measuring the current and voltage.

The thermal resistance of a device is a necessary design parameter since it determines the maximum steady state power that the device will accept under a given set of conditions. The technique and circuit presented allow the designer to measure the actual temperature rise of the junction, either in a standard heat sink or in his prototype design. (*Reprinted with permission from Hoffman Semiconductor product Application News, Nov.-Dec.* 1959. *Hoffman Electronics Corp.*, 1001 *Arden Drive, El Monte, Calif.*

[1] R. F. Gates and R. A. Johnson, Semiconductor Products, 2, #7, July 1959, p. 21

FOR MORE INFORMATION CIRCLE 103 ON READER-SERVICE CARD

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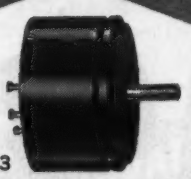
Type 3173
⅞" dia. rotary

Type 2064
Dual-element rectangular rectilinear



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CIRCLE 22 ON READER-SERVICE CARD

Flux-Responsive Memory Drum

A new digital magnetic memory drum, termed the Dynastat, in which readout is independent of drum speed has been developed to provide variable delay in automatic inspection devices, program control for automatic machine tools and test equipment, and synchronous conversion of binary codes from parallel to series and reverse.

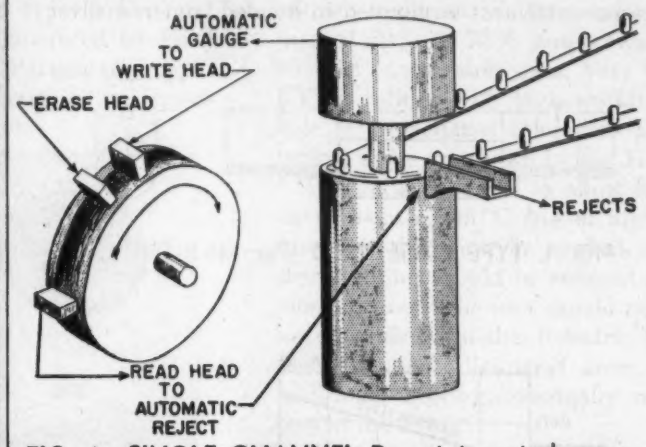


FIG. 1. SINGLE CHANNEL Dynastat controls gage for delayed application of go-no-go information in sizing of small parts.

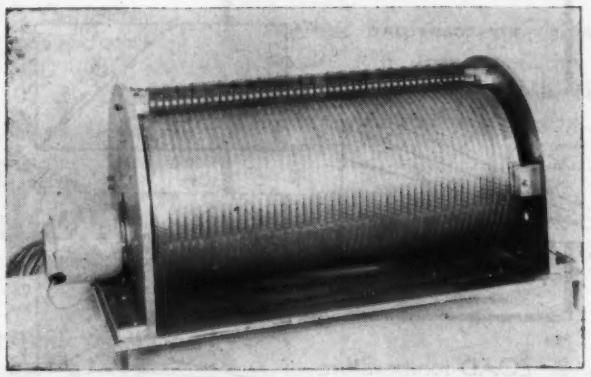
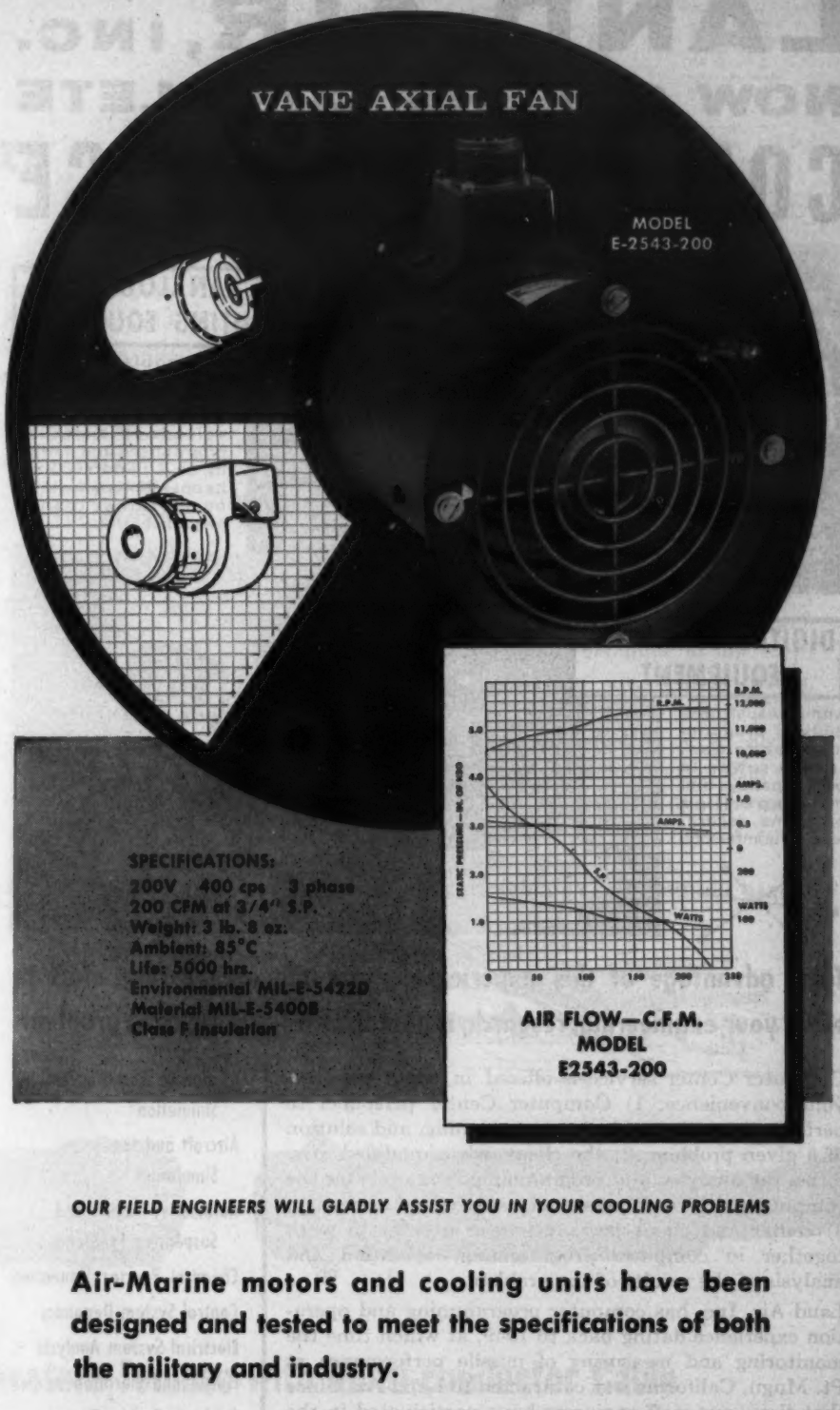


FIG. 2. STEPPING Motor positions 15,000-bit Dynastat memory drum.

Unlike conventional computer-type drums which depend on relative motion between the read head and the spot-magnetized record to induce an output in the millivolt range, the recorded spot acts as the trigger for a bistable magnetic amplifier which is contained in the read head. During the "writing" operation a spot of magnetic material on the drum is magnetized with one polarity for "zero", and the opposite polarity for "one". When the read head encounters a "zero" polarity spot, its output signal is zero; when opposite a "one" polarity spot, the output snaps to full voltage (Fig. 1).

Dynastat drums may consist of a single information channel or of as many parallel channels as are required to handle binary words of any size (Fig. 2). Special power supplies and output matching for operation into low impedance transistor circuits, or for high impedance operation into cold cathode matrixes are available. Complete information is available from the developers, *Consolidated Controls Corp., Bethel, Conn.*

FOR MORE INFORMATION CIRCLE 104 ON READER-SERVICE CARD



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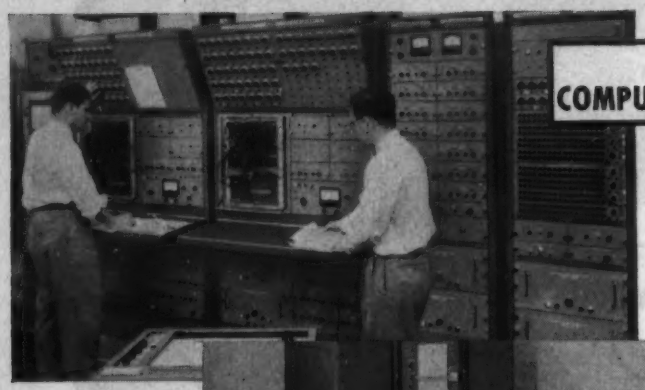

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Land-Air, Inc. has computer programming and operation experience dating back to 1949, at which time the monitoring and measuring of missile performance at Pt. Mugu, California was contracted to Land-Air. Since that time, our staff engineers have participated in the solution of a wide variety of problems in many different types of industry. This experience is available to clients who do not have computing equipment available, who wish to gain experience with computing equipment, or who require additional personnel or computer time to supplement their own facilities. In all cases, it is the objective of the Land-Air Computing Center to apply creative efforts to obtain the best solution to problems, with positive results obtained with a minimum of computing and programming time.

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CIRCLE 24 ON READER-SERVICE CARD

Military End-Use Resistors

Metal film "Metallux" resistors in ¼ to 2 watt nominal sizes meeting the stringent requirements of MIL-R-19074 B are now available in type CASE/ORO (Fig. 1). These are completely sealed axial lead units affording complete protection against moisture.

"Metallux" resistors are constructed of a nickel-chrome film on a cylindrical ceramic form, with the resistive element terminated in bonded, sintered silver

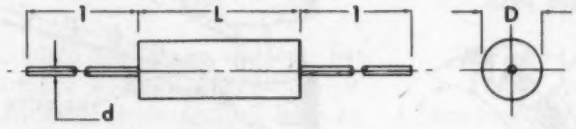


FIG. 1. TYPE CASE/ORO (Per Mil-R-19074B)

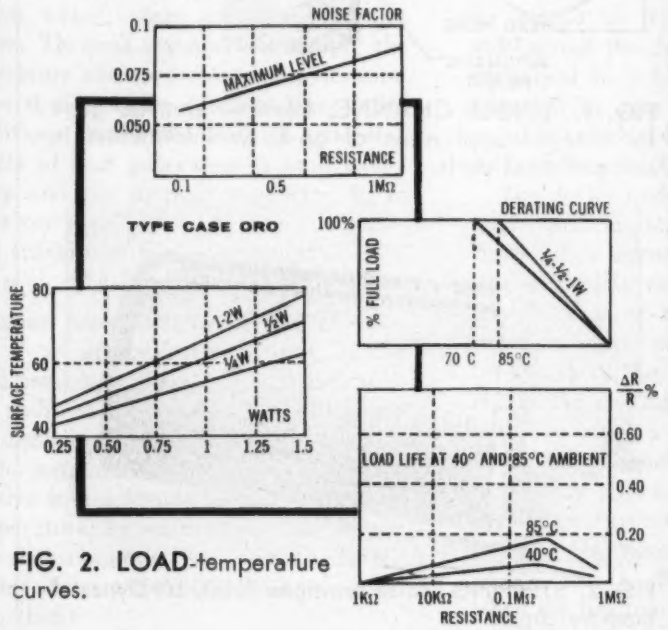


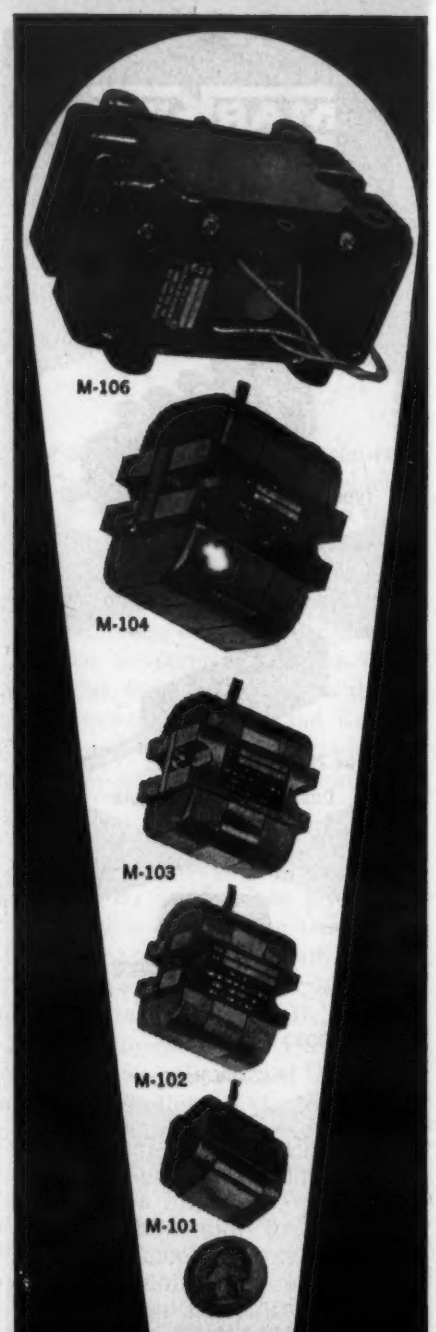
FIG. 2. LOAD-temperature curves.

Type	Dimensions in Inches				Resistance Range		Maximum Volts
	L	D	l	d	Minimum	Maximum	
CASE/ORO ¼	.670	.236	1.38	#23	.1Ω	1M	300
CASE/ORO ½	.866	.315	1.38	#23	.1Ω	1M	350
CASE/ORO 1	1.142	.394	1.38	#20	.1Ω	2M	500
CASE/ORO 2	2.000	.512	1.97	#20	.1Ω	2.5M	750

TABLE 1. DIMENSIONS of Type Case/Oro resistor are keyed to Fig. 1 for ¼ to 2 watt sizes.

ends and completely insulated with a polymerized silicone varnish. This type of construction provides the desirable features of both composition and wirewound types. Typical characteristic curves are shown in Fig. 2. (*From 5-page data folder, Mepco, Inc.*, 35 *Abbett Ave., Morristown, N. J.*)

FOR THIS LITERATURE CIRCLE 105 ON READER-SERVICE CARD



TORQUE MOTORS
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SPECIFICATIONS*

MODEL	101	102	103	104	106
Stroke (in.)	±0.000	±0.007	±0.008	±0.015	±0.020
Stroking Radius (in.)	0.650	0.563	0.750	0.906	1.250
Maximum Force (lbs)	2.5	5.0	8.0	13.0	15.0
Hysteresis (%)	2	2	2	2	2
Resonant Frequency (cps)	950	775	900	400	250
Weight (oz.)	3¼	6	10	22	55

*Special models available with rotary outputs or dry-coil construction.

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CIRCLE 25 ON READER-SERVICE CARD

High Power Ceramic Capacitors

A high power line of ceramic-type power and transmitting capacitors has been announced by Hi-Q Division of Aerovox, Olean, N. Y. Particularly applicable to inductive and dielectric heating and transmitting applications, these units provide space savings of 50% to 95% and weight savings of 25% to 95% of comparable units. Very high HF Current and KVAR ratings with high working voltages are available in capacitance tolerances as low as 5%. Three typical styles are shown in Fig. 1.

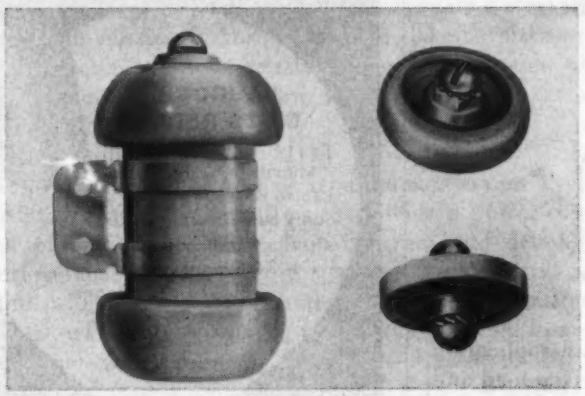

FIG. 1. HPA (lower right) and HPB Capacitors (upper right) are rated at 2500 and 3500 vdc working potentials respectively. Type HPD (left) is rated in capacities of 2000 $\mu\mu$f at 8500 vdc or ac working or 6000 v HF peak.

The units are rated to allow for a 30°C rise above an ambient of 45°C and at higher ambient temperatures derating must be applied. At 60°C ambient the power rating should be reduced by 30%. The surface temperature of the unit should not exceed 120°C since beyond this point the dielectric losses become greater than the heat dissipated from the surface causing additional heating, eventually resulting in deterioration of the unit.

Heating of these units consists of that internally generated and that absorbed from adjacent high heat sources. Internal heating is caused by dielectric and I^2R losses.

As the frequency increases, the dielectric losses generally will drop since the voltage decreases with decreasing reactance, while the I^2R losses increase as the current increases (Fig. 2). For capacitors of standard design at higher frequencies the I^2R losses become much greater than the dielectric losses due to decreased reactance and the current is thus the limiting factor in the rating of the capacitor. Under these conditions 90% of the heat is caused by current losses.

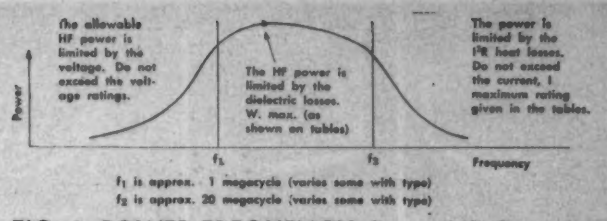
The allowable HF power is limited by the voltage. Do not exceed the voltage ratings.
The HF power is limited by the dielectric losses. W. max. (as shown on tables)
The power is limited by the I²R heat losses. Do not exceed the current, I maximum rating given in the tables.
Power
f1
f2
Frequency
f1 is approx. 1 megacycle (varies some with type)
f2 is approx. 20 megacycle (varies some with type)

FIG. 2. POWER-FREQUENCY Curve, HP Ceramic Capacitors.

The ratings given for these capacitors consider all of the interrelated factors and application requires only that the voltage, current and KVAR ratings are not exceeded. Aerovox HP Ceramic Capacitors perform satisfactorily to frequencies over 1,000 megacycles and the upper usable frequency is limited by the inductance in the mounting. The terminals are designed to reduce this inductance to a minimum.

HP ceramic units are rated as high as 50 amps RF current and 30 KVAR in air. Under certain conditions use in oil allows increased rating. These units are made under an exclusive U. S. A. license from Le Condensateur Ceramique in France. The new units are listed in a 30-page Ceramic Capacitor catalog, free on request from the *Hi-Q Division, Aerovox Corporation, Myrtle Beach, So. Carolina.*

FOR THIS LITERATURE CIRCLE 106 ON READER-SERVICE CARD

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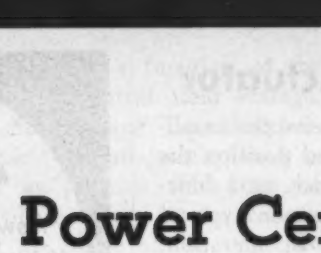

5-Y-8822
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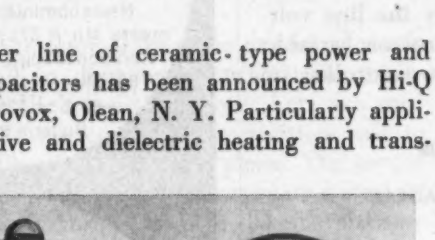

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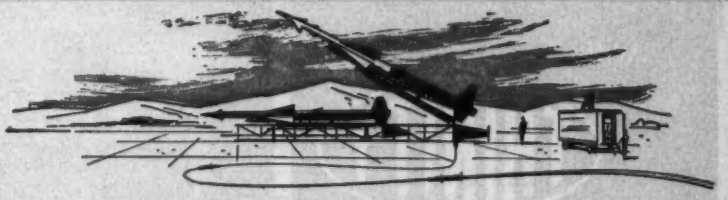

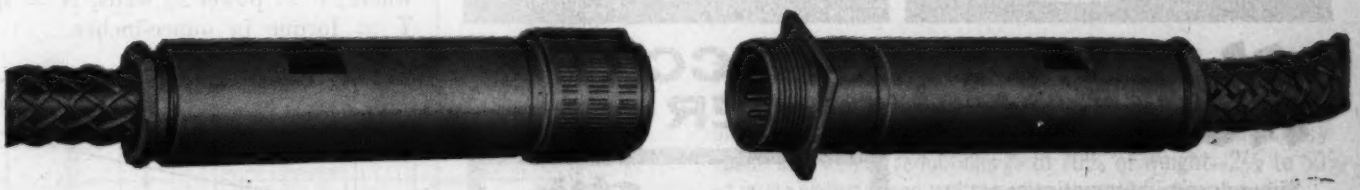

Why it pays you to specify

Bendix QWL Electrical Connectors for use with Multi-conductor Cable

For use with multi-conductor cable on missile launching, ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features: • The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts. • The fast mating and disconnecting of a modified double stub thread. • The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.) • The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish. • The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory. • The watertight connector assembly assured by neoprene sealing gaskets. • The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip. • Prevention of inadvertent loosening insured by a left-hand accessory thread. • The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

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Assembly dry-boxes

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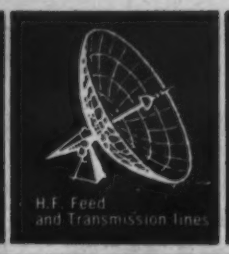
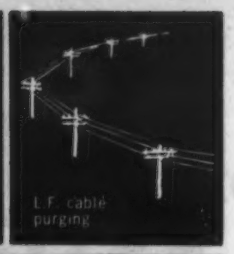

H.F. Feed and Transmission lines


L.F. cable purging

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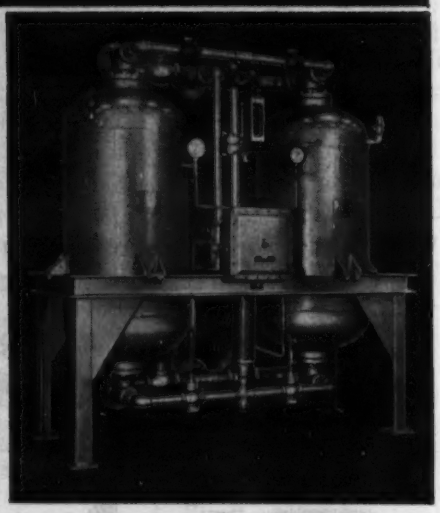

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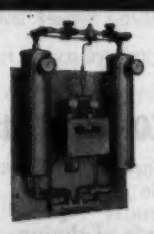

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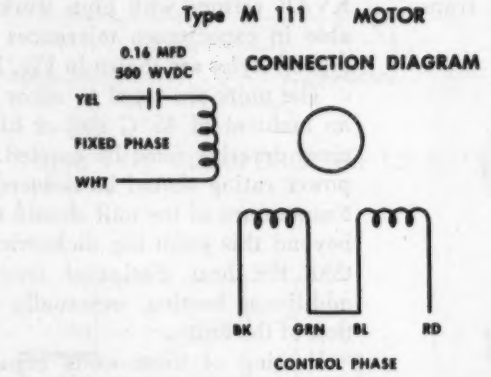
The Servo Control Actuator

The function of the actuator is to receive the amplified error signal from the controller and position the load and usually the feedback data device, as a function of the error signal. The most common type of actuator is the two-phase servo motor. In operation, one phase, called the main or fixed phase, is connected to a constant reference voltage, usually the line voltage. The other phase, called the control or variable phase, is connected to the output of the controller, or amplifier.

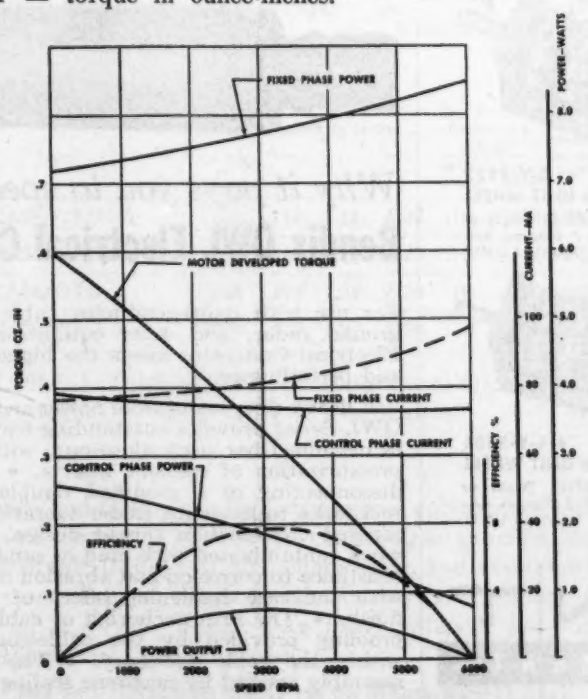


The choice of a motor for a particular application is governed by the requirements of the driven load and the available power source. Secondary factors are physical properties and any special environmental requirements of the system.

Power output of instrument control motors is usually expressed in watts rather than the more conventional horsepower used to rate larger motors. Power output is proportional to speed and torque. The conventional horsepower equation when reduced to watts, rpm and ounce-inches becomes:

$$P \cong \frac{3}{4} \times \frac{N}{1000} \times T$$

where: P = power in watts, N = speed in rpm, and T = torque in ounce-inches.



FIRST AGAIN!

New Babcock 10 amp Magnetic Latching Relay

New subminiature Model BR-9, meets Mil R 5757C, 25018, with vibration to 30g @10 — 2000 cps, 50g shock @11 millisec over —65°C to 125°C range. Bulletin BR-594.

BABCOCK BR-1S RELAY

Miniature, hermetically sealed BR-1SZ requires only 5 mw power, features very critical pull-in to drop-out ratios, 100,000 op. min. and —65°C to 125°C ranges. Meets Mil R 5757C, 6106C, 25018. Bulletin BR-593.

BABCOCK RELAYS

BABCOCK BR-7 RELAY

Subminiature 10 amp, DPDT relay with 0.2" grid spaced header accepts 30g vibration @10 — 2000 cps, 50g shock @11 millisec. over range of —65°C to 125°C. 100,000 op. min. @+125°C. Meets Mil R 5757C, 25018. Bulletin BR-592.

BABCOCK BR-8 RELAY

Subminiature A. C. or D. C. crystal can relay, 250,000 op. min. @+25°C. Vibration, 30g, 40 — 2000 cps. at —65°C to +125°C. Available with adjustments for repeatability over millions of operations. Meets Mil R 5757C, 25018. Bulletin BR-591.

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IRE SHOW BOOTH M-15
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The motor produces torque as a function of the quadrature component of the control field voltage, with respect to the main field voltage. It is therefore advantageous to have these two voltage displaced as close to 90° electrically as possible. This can be achieved by shifting the phase of the carrier voltage in the amplifier, shifting the phase of the reference voltage in the main phase or by a combination of these two methods.

The squirrel cage rotor of the servo or control motor is made as small in diameter as practicable to insure low inertia. High resistance rotor bars are used to help determine the control characteristics and to prevent the tendency to run single phase. The torque vs speed curves of these motors approximate a straight line with maximum torque at stall. Their relatively high torque and low inertia make them capable of high accelerations to follow rapidly changing error signals.

In example, the type M111 115v 400 cps Servo Motor is designed to operate from its companion Type SA2005 Transistor Amplifier to provide a power output of 0.95 watts. Connection diagram and detailed performance curves for this motor are illustrated. Dimensions of the M111 motor are 1-1/16" diameter x 1-27/64" long. (*From 68-page catalog, Mechatronic Development Apparatus, MDA-59.—Mechatrol Div., Servomechanisms, Inc.,* 1200 *Prospect Ave., Westbury, N. Y.*)

FOR THIS LITERATURE CIRCLE 107 ON READER-SERVICE CARD

Expanded Semiconductor Line Announced

The Sperry Semiconductor Division of Sperry Rand Corp. has announced an expansion of their semiconductor product line by an addition of fortyfour new transistor and subminiature diode types.

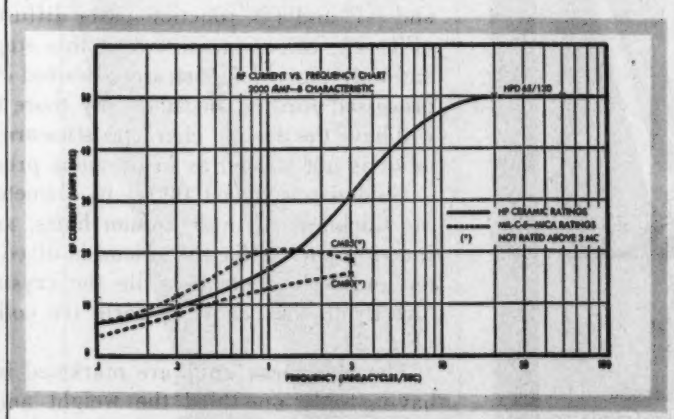
The new additions are said to reflect a thorough analysis of field requirements recently made by the Sperry product planning department. General purpose silicon alloy types already including and military types 2N1025 and 2N1026 will be augmented by 2N-327A, 2N328A, and 2N39A types, the 2N1034-2N1037 series, and the 2N1219-2N1223 series.

High voltage silicon transistors of the EIA type 2N1275 and several new 60v and 100v devices will be added to the 15-100 volt PNP silicon transistors now in production. All Sperry transistors are baked at 200°C for 200 hours for thermal stability.

New EIA diodes will include switching and high-conduction types, with special emphasis on computer diodes featuring excellent recovery characteristics (0.3 μsec to 400Kohms), by high uniform forward conductance (up to 400 ma@ 1.0v) and extremely low reverse leakage. All diodes are subjected to an extensive bakeout at 200°C; also a triple check of the hermetic seal—a 16-hr humidity cycle and two separate hydrostatic tests at 100 psi. Electrical characteristics are checked before and after these tests. Complete information on specifications, price and delivery is available from the *Marketing Dept., Sperry Semiconductor Div., Sperry Rand Corp., South Norwalk, Conn.*

FOR MORE INFORMATION CIRCLE 108 ON READER-SERVICE CARD

Hi-Q CERAMIC POWER AND TRANSMITTING CAPACITORS



Designed for wide applications in transmitting and communications equipments, industrial high frequency applications and medical apparatus, Hi-Q HP capacitors offer extraordinary space and weight reductions (5 to 70% of weight—2½ to 50% of space volume) and performance characteristics superior to comparable mica capacitors.
Engineered for high frequency operations, the ceramic dielectric retains its properties at frequencies above 1000 megacycles. HP capacitors have much higher current ratings for a given size than comparable mica units.
They can be operated at higher temperatures without derating...105°C versus 70°C for mica before derating for voltage...45°C versus 30°C before derating for current.
HP capacitors will meet all the requirements of MIL-C-5A for moisture resistance.

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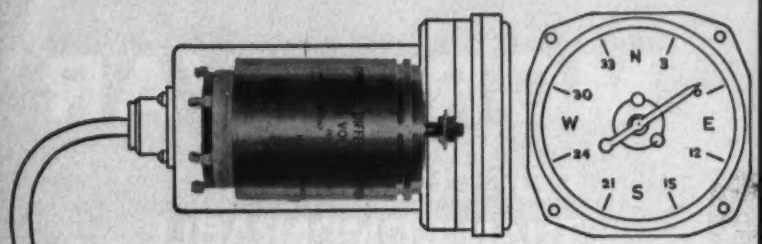
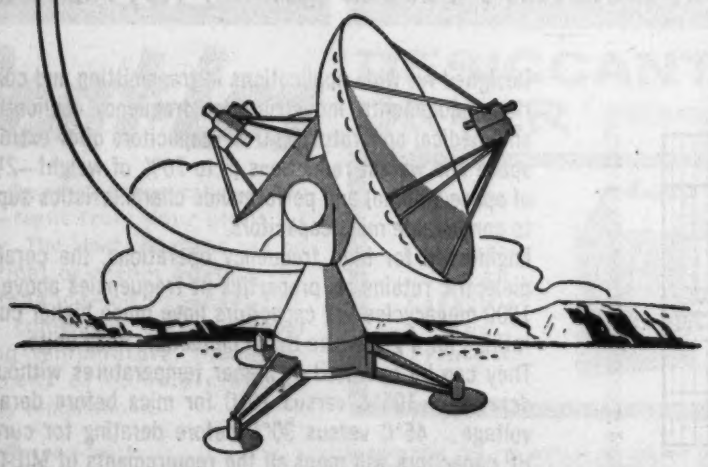
60-CYCLE SYNCHRO INDICATOR



Now available a 23TR6a Synchro Receiver conveniently packaged for immediate installation in ground support equipment consoles or shipboard installations. Your choice of dial presentations which will accurately display the angular or position information received from a remote synchro transmitter. The receiver is ready for front or rear mounting in a 3¾" panel cutout with four .144 holes equally spaced on 3.5 diameter. The receptacle provided on the receiver mates with an AN3106-14S-2S plug. Power requirements are 115 volt, 60 cycle using 5 watts. The receiver is pressure sealed by "O" rings for protection against sand, dust and moisture. The synchro contained in this indicator meets the requirements of MIL-S-20708.



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CIRCLE 88 ON READER-SERVICE CARD

New Mesa Transistor Characteristics Tightly Controlled

Advanced diffusion techniques carried out in a "controlled conditions" environment are credited by engineers of the National Semiconductor Corporation, Danbury, Conn., with success in meeting tight military specifications for two new types of NPN transistors, the NS200, for switching applications in computer circuitry, and the NS300, for high frequency amplification in video amplifiers, I. F. strips and telemetering, etc. These temporary designations are assigned for use pending the assignment of E.I.A. type numbers.

Comparison between characteristics uniformily exhibited by the new transistors are compared in the table below with the best performance previously accomplished in comparable devices. Also, beta linearity of the new transistor is said to be excellent over a wide range of collector current, with beta falloff from 1 to 100 milliamperes being less than 35% of peak value.

	National Semiconductor Transistors Types		Best Similar Units
Characteristics	NS200	NS300	
Output Capacitance	5$\mu\mu$f	5$\mu\mu$f	6$\mu\mu$f min.
Leakage Current	3 μamp	5 μamp	30-50 μamp
Guaranteed Minimum Gain-bandwidth product	200 mc	200 mc	70 mc
Collector saturation Resistance	35 ohms	40	50-60 ohms

Manufacture of the units at the Danbury plant starts with the growing of silicon crystals from materials of specified purity. The completed crystals are then sliced and NP and PN junction pairs diffused on its surface (Fig. 1). Slices are tested at this stage of production and only those demonstrating desired characteristics are processed further. Because only those transistors which will have the desired characteristics are processed, costly labor is not wasted as in previous production methods.

Gold wires, only 0.0005" in diameter, less than half the thickness of most human hairs, are welded to the junction pairs after the silicon is diced to provide emitter and base contacts while the crystal die is alloyed directly to the header to form the collector connection (Fig. 2).

The new mesa units are marketed in T-18 packages, having only one-third the weight and one-fourth the volume of TO-5 packaged units. All mesa transistors are heat soaked at 300°C, pressure-bomb tested, "shock" temperature cycled, and tested for resistance to vibration and mechanical shock. Life tests, which also include testing the transistors above their rated power level and at high ambient temperatures, reveal a high degree of stability.

FOR MORE INFORMATION CIRCLE 240 ON READER-SERVICE CARD

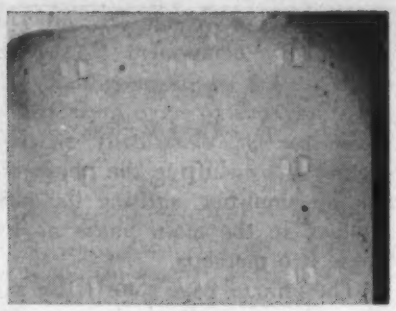
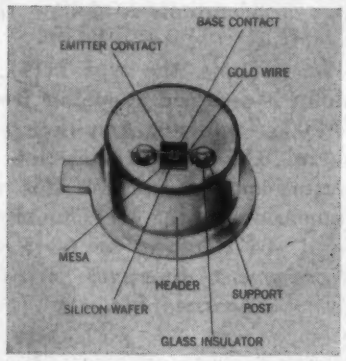
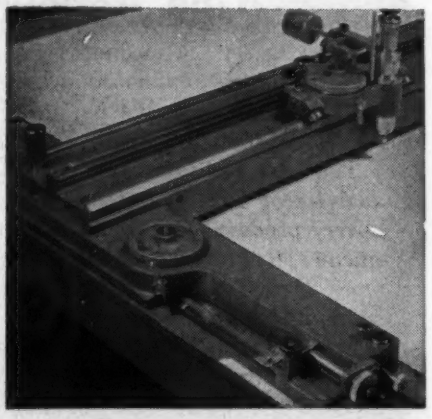


FIG. 1. DIFFUSION of up to 500 junction pairs on one silicon slice provides 500 identical transistors.

FIG. 2. ONLY TESTED dice are assembled into transistors.





A BETTER PLOTTER

for Precision Layout of Grid Systems and Coordinate Positions

The Coordinatograph, a new, better plotting instrument, is now being used for all types of precision layouts. It plots within .001" over a 47½" x 47½" working table. Rack and pinion construction for counter dials assures accurate measurements. 7 diameter pricker microscope permits observation and plotting in one operation. Radii from 12" to 40" can be plotted with beam compass. Vertically laminated plywood table. Vibration-free tripod mount. Write now for free folder.

AERO SERVICE CORPORATION
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CIRCLE 89 ON READER-SERVICE CARD

Phototransistor Applications

New GT PNP Germanium alloy junction phototransistors are miniature light controlled devices which are useful in many military and industrial applications where light is used to activate electronic equipment such as punched card and tape readouts in computer systems.

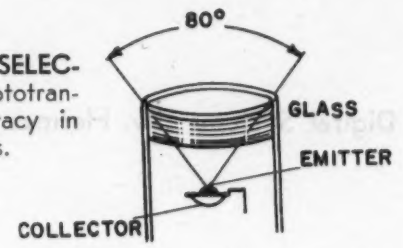


FIG. 1. HIGH SELECTIVITY of new phototransistor aids accuracy in positioning systems.

The light-sensitive area of the GT Phototransistor is 1.1 x 10^{-3} sq. in. (Fig. 1). The small size of this region permits their use in very fine positioning systems. This selectivity and sensitivity may be further increased by use of suitable lens systems.

The response of a photo-conductor to light excitation to a first order approximation is a function of the following considerations:

1) n_c = number of conductive pairs and is proportional to n, the number of photons with energy greater than the threshold energy (i.e., the energy gap between the valence and the conduction bands).
2) $n = I/h\gamma$ where I is the light energy, h is Planck's constant, and γ = frequency (cps).

$$n_c \sim \frac{I}{h\gamma} = \frac{I}{k}\lambda$$

where λ is wavelength.

Where operation in the presence of high ambient light is required the circuit of Fig. 2 is useful, especially in the single frequency case. High resistance in

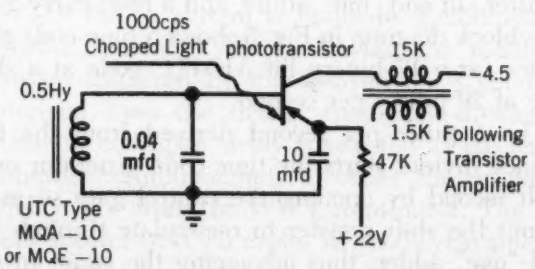


FIG. 2. TUNED CIRCUIT aids operation in High Ambient Light.

the emitter circuit degenerates response at frequencies other than that to which it is tuned. The capacitor would be omitted for operation over a wide frequency band. (*From 8-page technical Brochure G-190, General Transistor Corp., 91-27 138th Place, Jamaica 25, N. Y.*)

FOR THIS LITERATURE CIRCLE 109 ON READER-SERVICE CARD

Unique Electromechanical Interlock Performs Multiple Switching and Signalling Functions...

Fail-Safe Feature: Retaining pin design withstands 3,000 lbs. static side force

ELECTROID's model AM-1500 represents an entirely new concept in solenoid relay design, capable of mechanically retaining extremely high loads and simultaneously providing electrical interlock and positioning information. Switches can be set precisely to any predetermined operating tolerance. Various arrangements of independent interval SPDT switches can be operated at both the beginning and end of stroke.

This feature, by either internal or external electrical connection of the switches, can be made to interlock remote mechanical or electrical action. Provides high shock and vibration resistance (meets MIL-S-7029, MIL-E-5272 and MIL-S-4040 specifications). Fail-safe feature for aircraft, missiles and missile launchers.

Features of the AM-1500 (as illustrated)

- Retaining pin design withstands 3,000 lbs. static side force.
- Positive action overcomes 15 lbs. load @ 12 V.D.C. @ 72° F @ .250 stroke upon energizing.

Internal 10 lb. spring force repositions retaining pin upon deenergizing.

For special assistance with your particular electromagnetic requirements and for complete technical data on the AM-1500, write today.

ELECTROID
CORPORATION
99 Progress Street, Union, New Jersey
Tel.: MUrdock 6-8290

CIRCLE 31 ON READER-SERVICE CARD

Precision Timing System for Tracking and Control

REUBEN WASSERMAN and *PAUL HURNEY* Digital Systems Div. Hermes Electronics, Inc

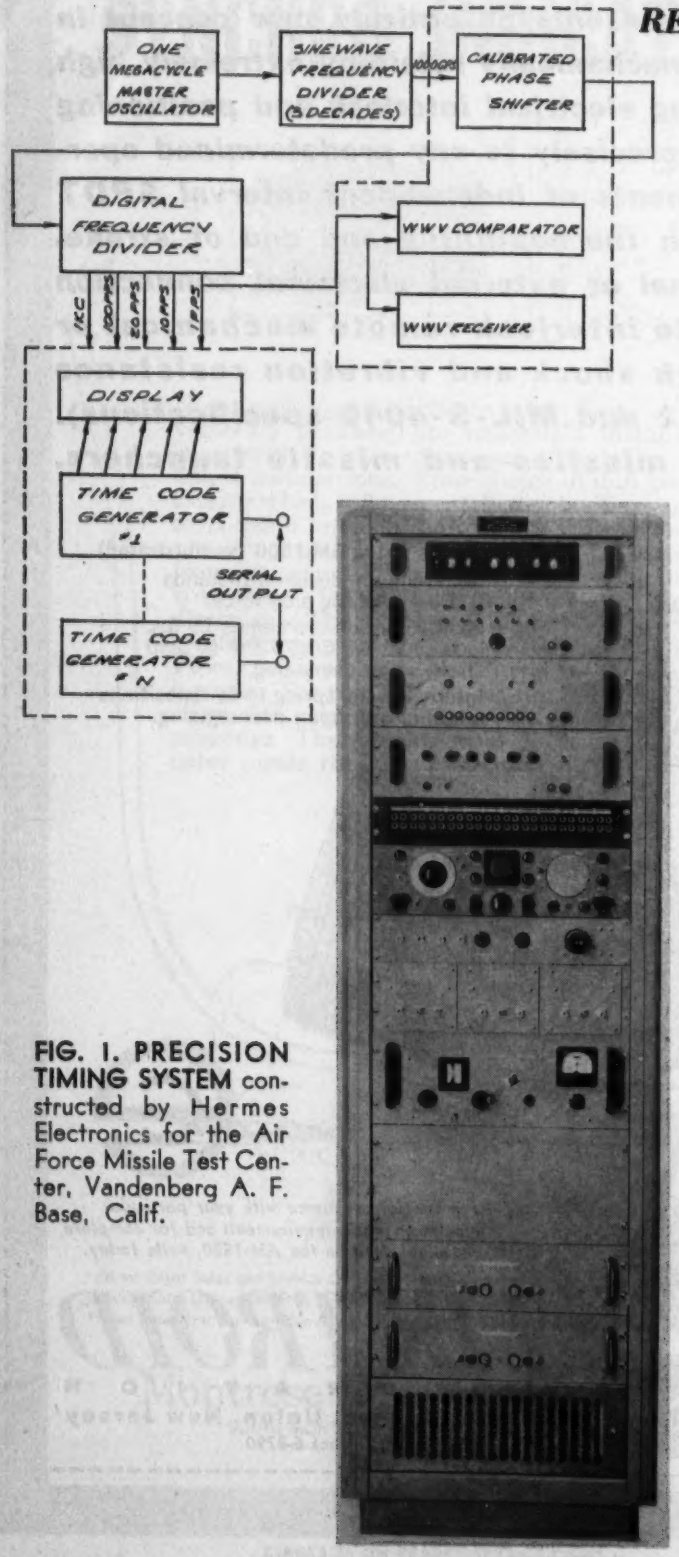


FIG. 1. PRECISION TIMING SYSTEM constructed by Hermes Electronics for the Air Force Missile Test Center, Vandenberg A. F. Base, Calif.

Precision Timing is one of the basic requirements needed in Missile Range Instrumentation to provide time reference for correlation of events and accurate measurement of missile positions and performance.

The precision timing system described in this article is composed of a number of pieces of equipment as shown in Fig. 1. The heart of any precision timing system is the Master oscillator which serves as the time base. A receiver for receiving Standard Time Signals from Radio-Station WWV and a comparator permits correction for drift error of the time base oscillator over long time periods. The time code generators generate time codes either as sequential clock pulses or in binary-code form to be fed directly to magnetic, photographic or oscillographic recording equipment.

Timing System Components

Time Base Oscillator. The time source is a one-megacycle ultra-stable oscillator with a frequency stability of better than one part in 10^9 per day which corresponds to a monthly error of about 0.01 second. The crystal of the oscillator is a contoured AT-cut quartz plate that vibrates in the fundamental shear mode with a Q in excess of 1,000,000. The crystal is permanently housed in an oven that consists of a dewar flask enclosed by a chromium-plated metallic container. The temperature is maintained to within 0.01°C by a closed loop heater circuit (Fig. 2).

Frequency Dividers. The division from one megacycle to one kilocycle is performed by three sinewave decade dividers which provide phase stability and jitter commensurate with the stability and jitter of the master oscillator. These dividers are of the regenerative heterodyne type (Fig. 3).

The 1000 cps sinewave is fed to a WWV comparator which is used to offset in either direction the time-code generators, so that the time-code generator can be brought into exact synchronization with time signals transmitted by Radio Station WWV.

The offset 100 cps sinewave is used as the master clock pulse throughout the timing system. Division from 1000 cycles is by binary digital dividing techniques. All pulses of lower repetition frequency are obtained by gating the 1000 cycle pulse with pulses of longer periods. This ensures that all timing code pulses will be precisely in synchronism to within a fraction of a microsecond.

Time-Code Generators. The time-code generators generate clock sequence pulses and numerically coded timing signals which are used to index data during data recording periods, thus providing a precise digital index in terms of lapsed time.[1]

The timing system can incorporate "n" number time code generators, each generating a particular time code and format as shown in Fig. 4. Each time-code generator derives its clock pulses from the frequency dividers, which serve as the slave drivers, and therefore ensure that the time code generators are clock synchronized. Each time-code generator is composed of an "n" bit length shift register, an add "one" adder, and a reset carry gate. The block diagram in Fig. 5 shows a time-code generator for a 17 binary bit AFMTC code at a shift rate of 20 pulses per second.

The 1 pulse per second derived from the frequency divider starts the time-code generator once each second by opening the control gate so as to permit the shift register to recirculate through the add "one" adder, thus advancing the count in the shift register by one. The reset carry gate senses the register at the count of sixty seconds and advances the count to minutes, resetting the count of sixty seconds to zero. This is repeated at the count of sixty minutes which advances the count to hours, resetting the count at sixty minutes to zero. At the

[1] "Tones Find Data in High-Speed Tape Systems" Electronics, November 21, 1958.
[2] "Computing Errors in Electronic Clocks." *Electronic Design*, October 15, 1958.

# of Missiles

count of 23 hours, 59 minutes, and 59 seconds, the time code generator resets to zero, and count starts over again.

The gate output control distinguishes between the binary "one" and "zero" from the shift register, and converts the binary bit into suitable form for recording on magnetic tape and oscillographs. A visual readout display indicates the time code shifted from the register for one second. The display provides a visual monitor of the operation of the time-code generator and provides an easy method for setting and adjusting the time.

WWV Comparator. The WWV comparator permits the timing system to be synchronized with WWV time signals through the use of an oscilloscope, a WWV receiver, and a self calibrated offset control. Fig. 6 is a block diagram of the WWV comparator. The 1000 cps sinewave is applied to the rotor of a resolver. The output of the stator circuit is a 1000 cps sinewave with its phase shifted from that of the input by an amount proportional to the shaft angle. Turning the resolver shaft, the phase shift can be varied continuously over an infinite range.

The timing system is manually synchronized to Radio Station WWV by having the oscilloscope sweep triggered by the delayed one-second pulse derived from the digital frequency divider. The amount of trigger delay is selected as the required number of milliseconds to offset the propagation delay time from the WWV transmitter. The WWV one-second ticks (5 cycles of 1000-cycle sinewave) and the one pulse per second (5 milliseconds) from the time system are summed through a resistive mixer to the vertical axis of the scope. The resolver is adjusted through a calibrated gear train until the WWV tone burst moves across the face of the scope and the leading edge of the tone burst is in phase with the leading edge of the 5 millisecond pulse. Assuming the propagation time calculation is correct, the timing system can be synchronized to within 100 μsec of WWV.

Each time-code generator is preset to the proper time corresponding to the next WWV time announcement. At the start of the WWV announcement the time generator is switched to the operate position. Since the time system's one pulse per second was previously synchronized, each timing generator will continue to generate the correct time codes.

To compensate for error due to uncertainty in propagation time delay, it is suggested that a record be kept of each new setting of the phase shift calibrator. The relative frequency drift between the timing system oscillator and WWV may be computed over a sufficient time period and the variation in propagation time delay will be averaged out.

Note that no Precision Timing System will keep perfect time due to the fact that the time base oscillator will have a finite error which cumulatively becomes significant over a sufficient time period. Consequently two controls are needed in the precision time system to obtain precise time operation. The first provides for presetting the correct time in each digital timing generator; the second provides for adjusting the oscillator frequency to compensate for frequency drift thus reducing the rate of time-error accumulation.

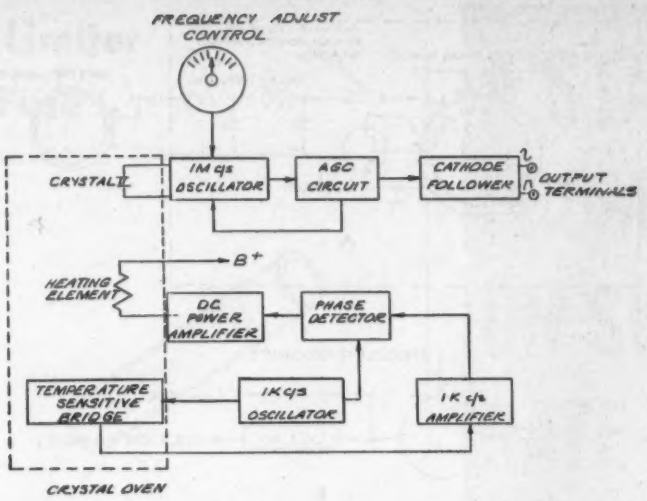


FIG. 2. ULTRA STABLE Oscillator operating at one megacycle is the heart of the Precision Timing System.

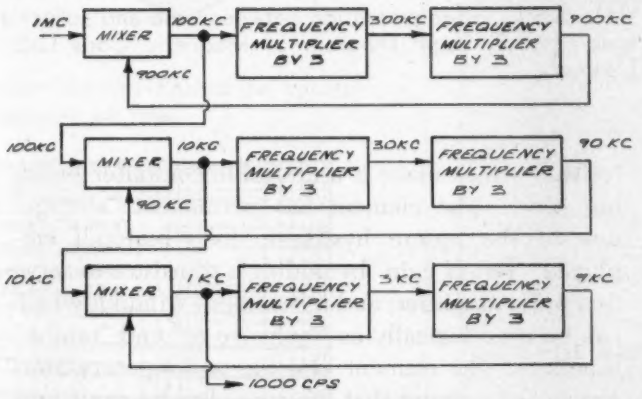


FIG. 3. SINEWAVE DIVIDER SYSTEM subdivides basic 1-mc frequency to obtain stable 1000 cps to drive counters.

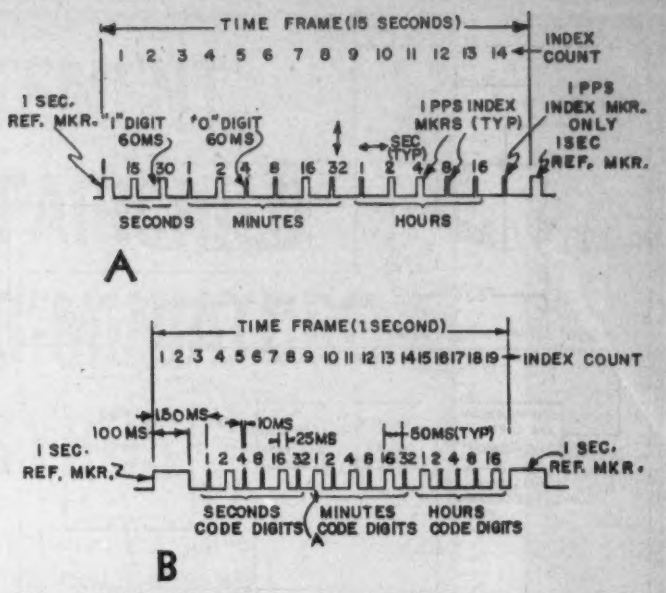


FIG. 4. TIME CODES in almost infinite variety can be generated by combining pulses and spaces of different lengths. Two typical pulse-width codes are shown; (A) is a 13-Digit, 1 pps; and (B) a 17-Digit, 20 pps code.

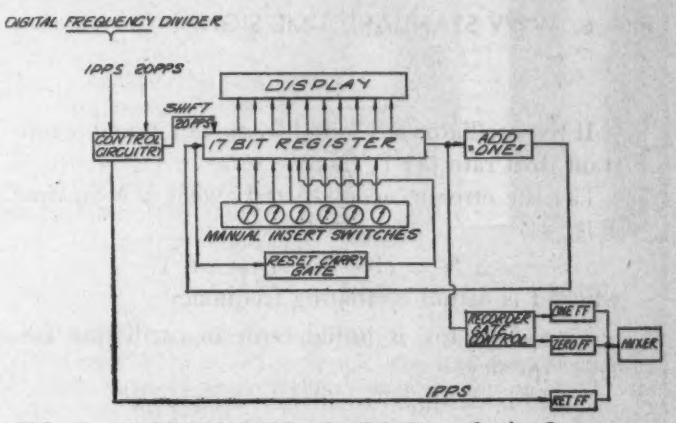


FIG. 5. 17 BINARY BIT AFMTC Time-Code Generator Block Diagram.

Cumulative Error in the Timing System

Long term stability of the master oscillator is determined by the accumulated count of cycles of the master oscillator compared to the accumulated count of the WWV standard. This is effectively done by making comparison with the broadcast time of WWV and the Timing System. The WWV comparison procedure determines the number of cycles that the time system has lost or gained since the last calibration time. From this information the average rate error of the oscillator can be calculated.

(*Continued on page* 40)

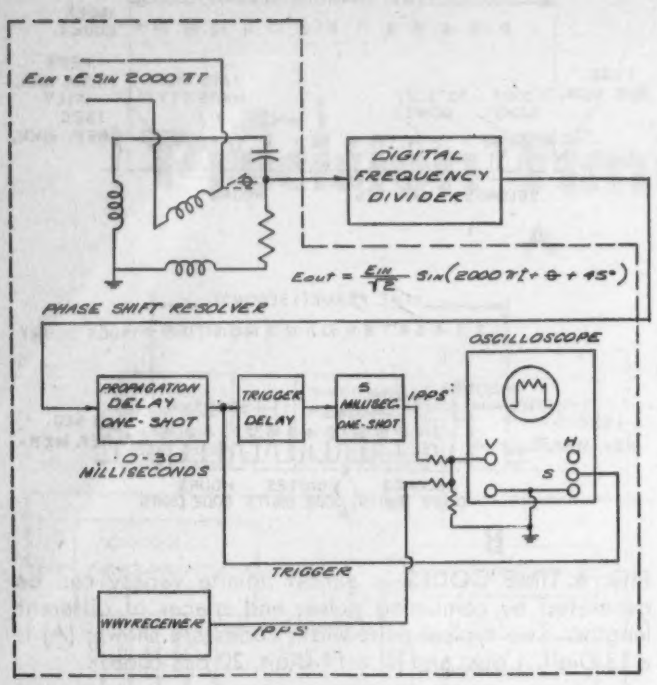


FIG. 6. WWV STANDARD TIME SIGNAL Comparator.

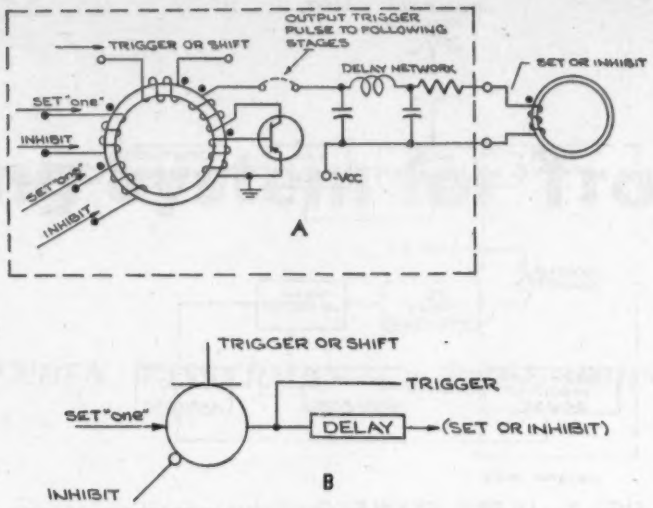


FIG. 7. MAGNETIC CORE LOGIC Element. (A) Schematic Diagram. Dots are placed so that current entering these terminals produce counter-clockwise flux in the magnetic circuit. Thus if a current pulse applied to any input winding sets the core in the "one" state, a trigger or shift pulse will reset the core to the "zero" state due to self-regeneration between base and collector windings. (B) Logic Diagram of Magnetic Core Logic Element.

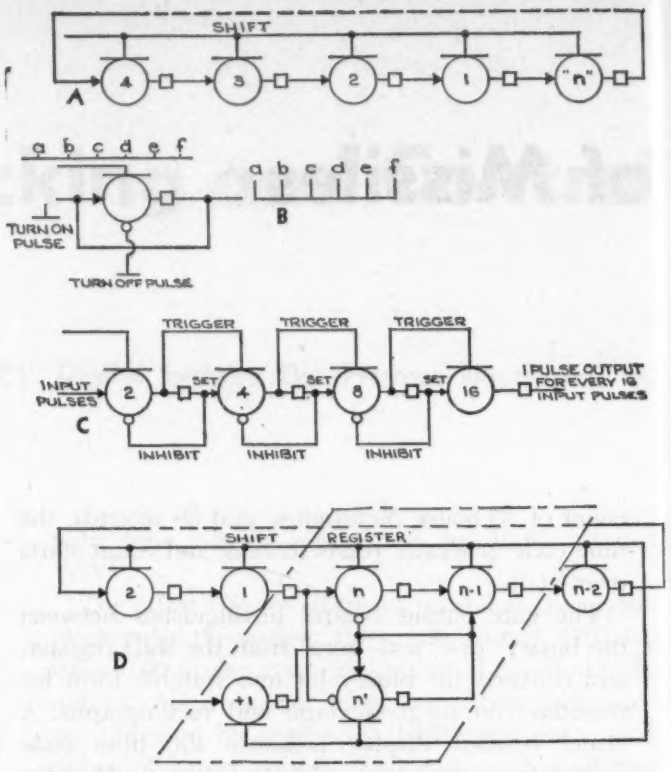


FIG. 8. FOUR FUNCTIONAL BLOCK combinations of Magnetic Core Elements comprise Time Code Generator: (A) Shift Register, (B) Dynamic Flip-flop, (C) Binary Counter (to 16) and (D) Complement Add "ONE" adder.

If the oscillator has initial frequency f, and a constant drift rate per f', then

(a) the error in accumulated cycles ΔN in time T is;

$$\Delta N = (f - fo)\,T + \tfrac{1}{2} f'\,T^2$$

where f is actual oscillating frequency

$(f - fo)$ is initial error in oscillation frequency

fo is designed oscillation frequency

(b) The error in units of time

$$\Delta T\ \mu\text{sec} = \left(\frac{f - fo}{fo}\,T + \frac{f'}{2fo}\,T^2\right)10^6 \text{ microseconds.}$$

If after one week of operation the calibrated phase shifter is advanced 3 milliseconds in order to synchronize the timing system to WWV, then the oscillator has generated 3000 fewer cycles out of a total of 6.048×10^{11} cycles. This is an error of approximately 5 parts in 10^9.

The total error may be attributed to an initial frequency setting error in addition to the drift rate. On an initial assumption that one-half the error (1.5 msec/week) is due to drift, and the remaining half is due to setting, using the above equation the setting error is 5×10^{-9} cycles ($f_o = 999{,}999.995$ cps) and the drift error is 1×10^{-9} cycles per day.

Circuits

The time code generators are constructed from one basic building block called a magnetic core logic element. This logic element has three characteristics which make it a desirable computer building block. The element has permanent "storage" due to the square hysteresic loop material employed; "power gain" by adding a transistor to serve as a pulse amplifier; and a two-input winding which can be used logically as "inclusive or" and "inhibit" functions. The element also has a temporary storage so as to ensure that the core element can transfer its stored information before receiving new information from previous cores. An R-L-C circuit in series with the core output provides the temporary storage.

These features are incorporated in the circuit shown in Fig. 7. The circuit is a grounded emitter type, one-shot blocking oscillator. The core in saturation has a loop gain less than one. On the vertical slope of the square hysteresis loop the loop gain is greater than one, and regeneration is possible. If the core is in the "one" state,— a trigger pulse applied will completely switch the core, due to regeneration between base and collector. If the core is in the "zero" state, the trigger pulse has no effect since the loop gain is less than one.

Fig. 8 shows the four basic functional blocks which constitute any time code generator that employs these magnetic core logic elements. The shift register (A) of any length stores the time word which is recirculated at every add "one" count. The dynamic flip-flop (B) is effectively a one stage circulating register, which serves as the gate control for circulating the shift register. The turn-off is determined by the binary counter (C) whose output inhibits the dynamic flip-flop at a count equal to the length of the circulating register.

The add "one" adder (D) operates in the binary complement for simplicity since the magnetic core element can be used only in "inclusive or" and "inhibit" and not in "and" gates. The Adder is effectively a subtractor in the sense that in straight binary arithmetic the operation is subtracting "one" (see Table I).

TABLE I. EQUIVALENT NOTATION IN DECIMAL, STRAIGHT BINARY AND BINARY COMPLEMENT SYSTEMS.

Decimal	Straight Binary	Binary Complement
0	0000	1111
1	0001	1110
2	0010	1101
3	0011	1100
4	0100	1011
5	0101	1010
6	0110	1001
7	0111	1000
8	1000	0111
9	1001	0110
Add 6	0110	1001
+1	+1	−1
7	0111	1000

Acknowledgements

The authors wish to acknowledge the technical contributions of Mr. John DeTurk and Mr. Richard L. Smith in the preparation of this article; and the assistance of the technical staff, Digital Systems Group, Hermes Electronics, Inc., in the building of the Precision Timing System.

FOR MORE INFORMATION CIRCLE 110 ON READER-SERVICE CARD

Solid-State Current Limiter is Faster-Acting Fuse

A one-shot non-indicating fast-acting current limiter, said to employ solid state principles, is available in standard fuse form and in new types for use in printed circuit applications (Fig. 1). The new devices feature extremely fast blow times (Fig. 2), as much as 400% faster than a standard fast blow fuse. Typically it blows in less than 1 millisecond at 316% of rated value. Typical resistance values of the device at room temperatures are shown in parens after the current rating of each size. The Solid State Current Limiter is a development of Microelectron, Inc., P. O. Box 24174, Los Angeles 24, Calif. A printed circuit fuse holder to accommodate the Type P200 Current Limiter is currently being developed.

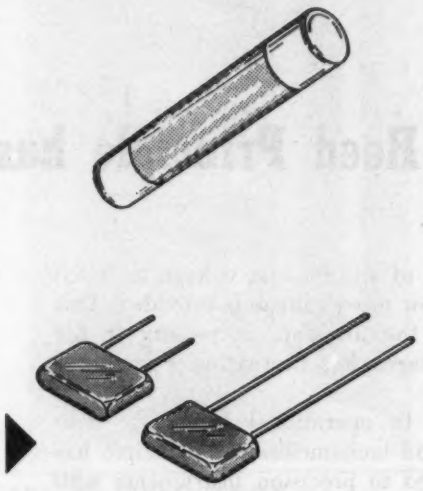
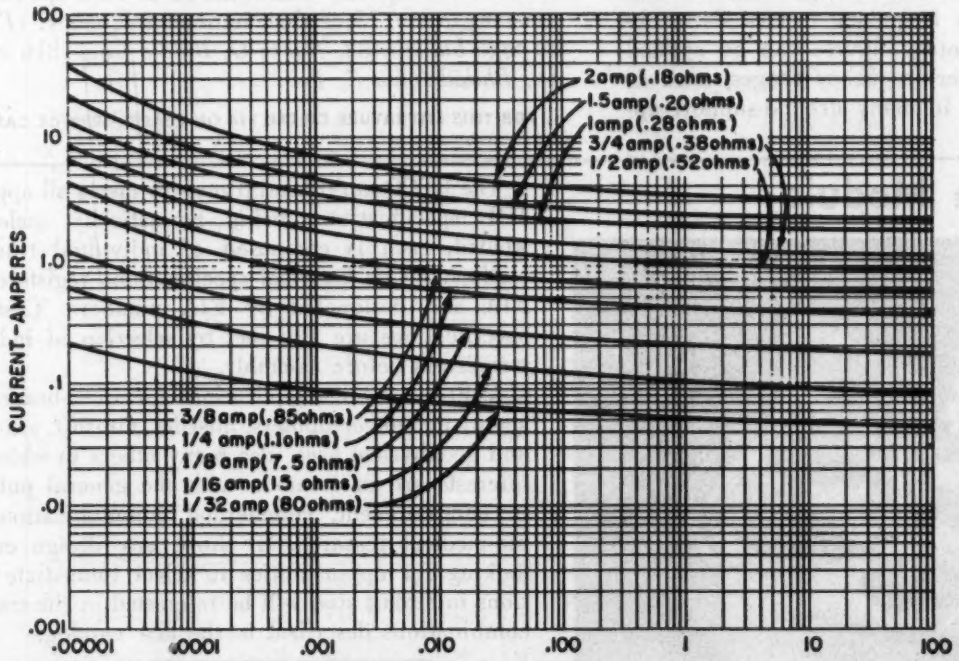


FIG. 1. FASTER-ACTING Solid State Current Limiter replaces conventional fast blow fuses (Model S 100) or is available for printed circuit applications in Model P 200.

FIG. 2. TIME-CURRENT CURVES, Series S-100 Current Limiter. Resistance values at room temperature are shown in parens for each capacity of fuse.



FOR MORE INFORMATION CIRCLE 113 ON READER-SERVICE CARD

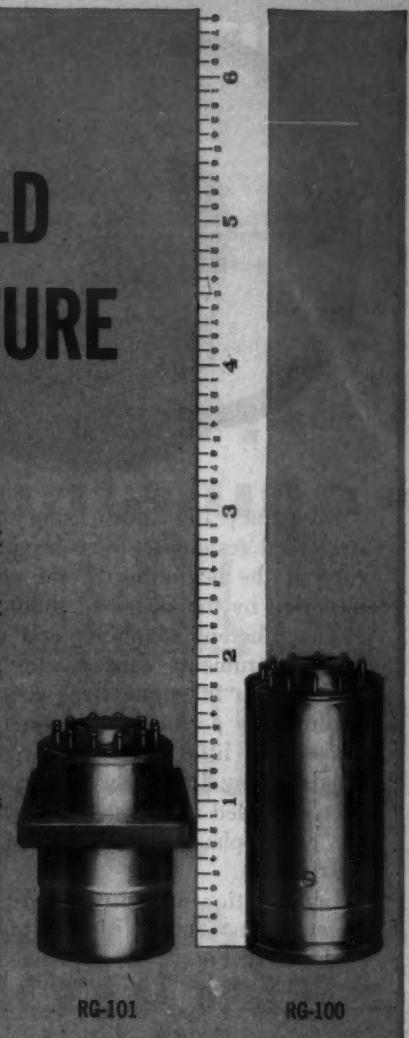
BOOK REVIEWS . . .

Guide to the Space Age, by C. W. Besserer and Hazel Besserer, Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y., 320 p., 6¾" x 9¾", $7.95. Over 5000 terms are defined, alphabetized and cross-referenced. Tables, formulas and standard coefficients plus "missile slang" terms make it a valuable reference for engineers reading the current literature.

Electromagnetic Fields, Energy, and Forces, by R. M. Fano, L. J. Chu, R. B. Adler, (1960) John Wiley & Sons, Inc., 440 Park Ave., So., New York 16, N. Y., 520 p., 6" x 9", $12.00, "Core Curriculum" textbook by three members of the faculty, Dept. of Electrical Engineering, Massachusetts Institute of Technology, is written on an undergraduate level.

A STATEMENT FROM FAIRCHILD ON SUB-MINIATURE RATE GYROS

Fairchild hasn't cornered the market on rate gyros. Other leading firms are also building them . . . But no one but Fairchild is building them as small, as rugged, as precisely and with so many exclusive features.



Fairchild's rate gyros are the smallest made. Type RG-101 is 15/16" diam. (exclusive of mounting flange) x 1⅝" long, weighs less than two ounces. Model RG-100 is slightly larger.

RG-101 RG-100

FAIRCHILD Rate Gyros Are So Rugged!—Take 150 g's of shock, and 30 g's to 2000 cps vibration, even at rates as low as 10° per second. This high shock resistance is due in part to Fairchild's exclusive design feature, where the torsion bar is not required to act as a support for the gimbal.

FAIRCHILD Rate Gyros Have Self-test Capabilities!—No need to pound fists on gyro mounting bulkheads or to jump up and down on wings to check Fairchild gyro performance. Fairchild gyros have self-test capabilities designed in for remote check-out. The gyro gimbal system's freedom of movement can be checked over its entire range of travel, from limit stop to limit stop in most designs. Friction or threshold level, sensitivity, and even damping ratio can be checked from the blockhouse.

FAIRCHILD Rate Gyros Have Uniform, Constant Damping!—For any required percentage of critical within ±15% and over the entire operating temperature range of —40°F to +200°F. This is accomplished in the Fairchild design by using the fluid that fills the gyro in two ways. First, the fluid is the damping medium. Second, it acts as a hydraulic actuator to vary the shear damping gap as the temperature varies, thus compensating for changes in the fluid's own viscosity. Where less damping control is required, Fairchild also builds the smaller, less expensive Type RG-101.

OTHER OUTSTANDING CHARACTERISTICS OF FAIRCHILD GYROS

INPUT RATES (Full Scale) . . . ±5 to ±800 degs./sec.
MOTOR . . . 2 or 3 phase; 26V or 115V AC, 400 cps.
OUTPUT . . . 6V, 400 cps, phase sensitive. Other voltages and frequencies available on special order.
LINEARITY . . . 0.2% to half scale; 3.5% to full scale.
NULL . . . 15 to 40 mv total, in-phase and quadrature can be padded to negligible amounts.

For more information on Fairchild's Rate Gyros write

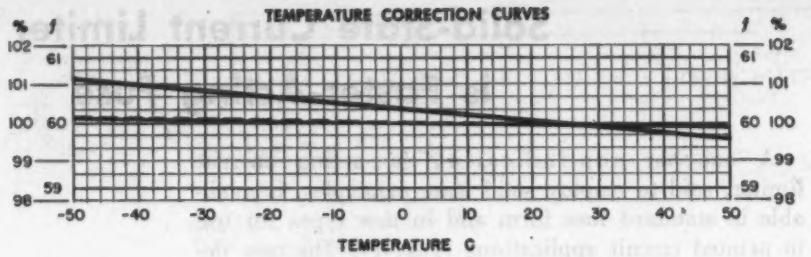
FAIRCHILD CONTROLS CORPORATION
COMPONENTS DIVISION
225 Park Avenue Hicksville, L. I., N. Y. • 6111 E. Washington Blvd. Los Angeles, Cal.
A Subsidiary of Fairchild Camera and Instrument Corporation

GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

CIRCLE 36 ON READER-SERVICE CARD

FIG. 1. TUNED REED resonance is principle of rugged, accurate frequency meters and new resonant frequency controls.

FIG. 2. PRECISION (dashed line) and standard (solid line) frequency meter temperature correction curves.



Resonant Reed Principle has New Applications

Frequency Indicators using the principle of tuned steel reed resonance were invented by Frahm in Europe at the beginning of the century and were first imported by the James G. Biddle Co. in 1910.

The inherent simplicity and unfailing accuracy of these instruments earned wide acceptance in many fields. Even in applications requiring continuous operation they performed accurately and dependably for years with little or no adjustment, maintenance or repair of any kind. However, this early superiority has been extended in recent years by basic research covering every phase of design and production of these instruments.

Construction of a direct-drive tuned-reed frequency meter mechanism used in the higher frequency ranges is shown in Fig. 1. An adjustment screw for obtaining the proper amplitude of vibration at voltage as much as 20% above or below rated voltage is provided. This adjustment changes the air gap, increasing it for higher-than-rated voltages, and decreasing it for lower voltages.

Originally limited to operational frequency indicating instruments and tachometers the principle has recently been extended to precision instruments with guaranteed accuracy to ±0.1% at room temperature, resonant reed relays, and resonant reed oscillator controls.

Typical temperature corrections for standard and precision 60 cps Frahm frequency meters shown in Fig. 2. The same percentage figures can be applied to Frahm meters in other frequency ranges, such as the 400 cps meter used in many ground-support applications.

Frequency-sensitive relays and oscillator controls simplify the transmission of a number of control signals over a single communication circuit of any type. Acting like bandpass filters with narrow response bandwidth, a single SPST contact can be provided for each relay reed within the range from 20 to 1000 cps. Transmitting components for a frequency telemetering system are the ROC Resonant Reed Oscillator Controls for maintaining oscillator frequencies within close limits, which are available for any nominal control frequency within the 20 to 1000 cps range, constant to ±0.15 of that nominal frequency. (*From* 20-*page bulletin* 32, *James G. Biddle Co.*, 1316 *Arch St., Philadelphia* 7, *Pa.*

FOR THIS LITERATURE CIRCLE 114 ON READER-SERVICE CARD

Multi-Headed Transistors New Design Module

New avenues in sub-miniaturization are being opened due to the availability of multi-headed transistors developed by the Electronic Transistors Corp., 9226 Hudson Blvd., North Bergen, N. J. Circuit designers can now specify a wide and growing number of combinations and permutations of transistor characteristics to be included within a single hermetically sealed transistor capsule (Fig. 1).

It has been established that the combination of individual transistors within the multi-headed package creates no interference, and that each transistor can be treated circuit-wise as if they were in separate, space consuming packages. The new transistors enable a space factor advantage of from two to three compared with components now in existence. They can be either supplied in plug-in socket types or wired-in versions.

The multi-headed transistor units are said to be 25% lower in price than combined prices of individual transistor units and are immediately available in combinations of the following types, with any two included in a JEDEC 30 package (Fig. 2):

2N428	Switching	2N482, 2N483 — High Frequency
2N404	Switching & Computer	2N484 — Entertainment
2N43	Audio Amplifier	
2N302	High Frequency	2N1372, 2N1374 — General Purpose

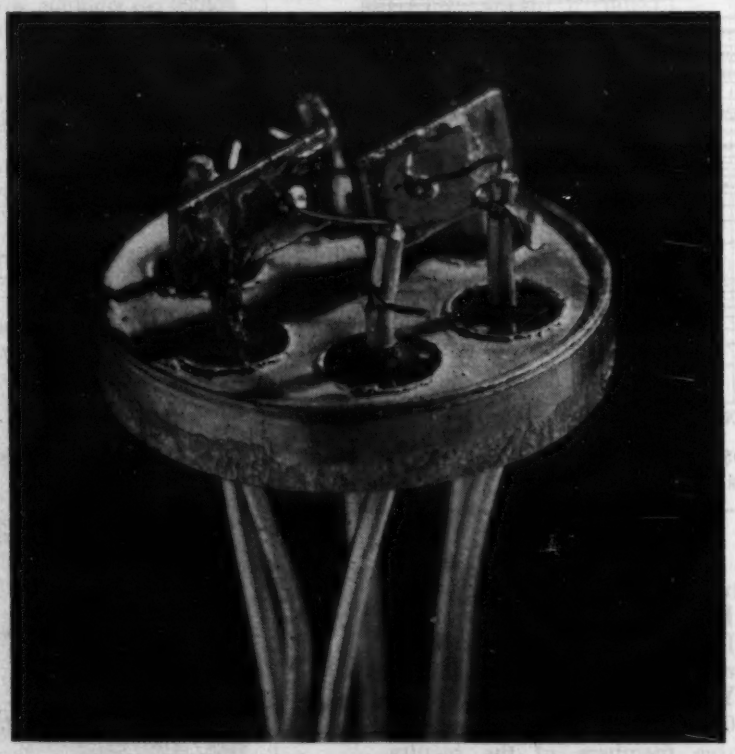


FIG. 1. UNCASED MULTIHEADED Transistor construction is shown in 10-times enlargement. New format saves space, weight and money in critical applications.

The ETCO multi-head transistor meets all applicable MIL specifications, being hermetically sealed and welded, each is composed of individual transistors conforming to electrical specifications registered with EIA and designated by EIA numbers. Customer's specifications are also met by selection of individual transistors before assembly.

Military systems applications for multi-headed transistors include computers, missiles, aircraft, space craft and geophysical uses, also many others in which their interests are in common with the general public, as in entertainment, commercial communications, and bio-medical research. In short, any design engineer looking for opportunities to effect immediate reductions in circuit size, will be interested in the transistor combinations described in the new catalog.

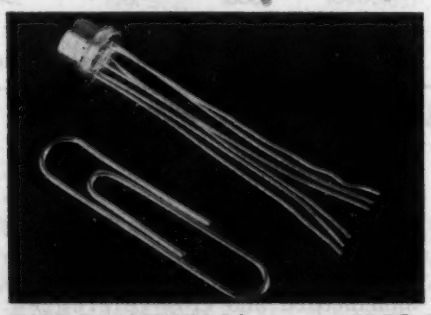
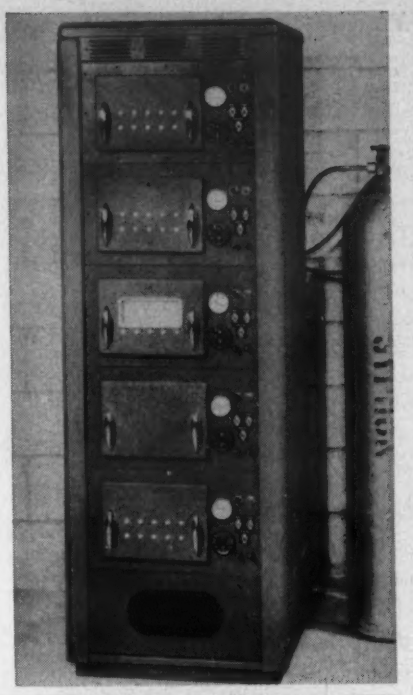


FIG. 2. TWO TRANSISTORS in one JEDEC 30 package (actual size) are isolated from each other circuitwise.

FOR MORE INFORMATION CIRCLE 115 ON READER-SERVICE CARD

Thermal Shock Chambers



Rack-mounted portable thermal test chambers providing accurate temperature control to ±0.2°F over a range of −100° to 500°F are mounted within inches of each other in the new 1060 Series testing facility manufactured by Delta Design, Inc., 7460 Girard Ave., La Jolla, Calif. Five separate 10″x7″x7″ chambers are shown in a rack occupying only four square feet of floor space.

Thermal shocking of electronic sub-assemblies is greatly simplified because the stainless steel test drawers with their contents can be shifted from a chamber having one temperature extreme to one at the opposite end of the scale in seconds. Also tests requiring alternate hot-and-cold cycling and subsequent temperature compensation can be achieved without prolonged warming-up and cooling periods.

All rack-mounted units are cooled with liquid CO_2, and have wrinkle enamel exteriors and stainless steel inner liners insulated by fiberglass. Heating is accomplished by 650-watt electric elements.

FOR MORE INFORMATION CIRCLE 116 ON READER-SERVICE CARD

RADIO FREQUENCY BAND CODE LETTERS VS. FREQUENCY

P-band		S-band			C-band Designation includes S_z through X_Y from 3.9-6.2 kmc/s			K-band			Q-band		
Freq.	λ	Sub	Freq.	λ	X-band			Sub	Freq.	λ	Sub	Freq.	λ
0.225	133.3	E	1.55	19.3				P	10.90	2.75	A	36.00	0.834
0.390	76.9		1.65	18.2	Sub	Freq.	λ		12.25	2.45		38.00	0.790
UHF Television Band Channels 14 through 83, 0.470 to 0.890 kmc/s		F	1.65	18.2	A	5.20	5.77	S	12.25	2.45	B	38.00	0.790
			1.85	16.2		5.50	5.45		13.25	2.26		40.00	0.750
L-band		T	1.85	16.2	Q	5.50	5.45	E	13.25	2.26	C	40.00	0.750
Sub	Freq.	λ	2.00	15.0		5.75	5.22		14.25	2.10		42.00	0.715
P	0.390	76.9	C	2.00	15.0	Y	5.75	5.22	C	14.25	2.10	D	42.00	0.715
	0.465	64.5		2.40	12.5		6.20	4.84		15.35	1.95		44.00	0.682
C	0.465	64.5	Q	2.40	12.5	D	6.20	4.84	U	15.35	1.95	E	44.00	0.682
	0.510	58.8		2.60	11.5		6.25	4.80		17.25	1.74		46.00	0.652
L	0.510	58.8	Y	2.60	11.5	B	6.25	4.80	T	17.25	1.74	V-band		
	0.725	41.4		2.70	11.1		6.90	4.35		20.50	1.46	Sub	Freq.	λ
Y	0.725	41.4	G	2.70	11.1	R	6.90	4.35	Q	20.50	1.46	A	46.00	0.652
	0.780	38.4		2.90	10.3		7.00	4.29		24.50	1.22		48 00	0.625
T	0.780	38.4	S	2.90	10.3	C	7.00	4.29	R	24.50	1.22	B	48.00	0.625
	0.900	33.3		3.10	9.68		8.50	3.53		26.50	1.13		50.00	0.600
S	0.900	33.3	A	3.10	9.68	L	8.50	3.53	M	26.50	1.13	C	50.00	0.600
	0.950	31.6		3.40	8.83		9.00	3.33		28.50	1.05		52.00	0.577
X	0.950	31.6	W	3.40	8.83	S	9.00	3.33	N	28.50	1.05	D	52.00	0.577
	1.150	26.1		3.70	8.11		9.60	3.13		30.70	0.977		54.00	0.556
K	1.150	26.1	H	3.70	8.11	X	9.60	3.13	L	30.70	0.977	E	54.00	0.556
	1.350	22.2		3.90	7.69		10.00	3.00		33.00	0.909		56.00	0.536
F	1.350	22.2	Z	3.90	7.69	F	10.00	3.00	A	33.00	0.909	K1-band Designation includes K_U through K_Q 15.35 to 24.5 kmc/s		
	1.450	20.7		4.20	7.15		10.25	2.93		36.00	0.834			
Z	1.450	20.7	D	4.20	7.15	K	10.25	2.93	Legend: Sub=identifying subletter. Freq.=band limits in kilomegacycles/sec. λ=equivalent wavelength in centimeters.					
	1.550	19.3		5.20	5.77		10.90	2.75						

(From "Encyclopedic Dictionary of Electronics and Nuclear Engineering," by Dr. Robert I. Sarbacher, [c. November 1959,] Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y.)

CIRCLE 37 ON READER-SERVICE CARD →

...for MINIATURIZATION

NEW! miniature BALL BUSHINGS for LINEAR MOTIONS

LOW FRICTION and WEAR
LASTING PRECISION ALIGNMENT
ELIMINATE BINDING and CHATTER
ZERO SHAKE or PLAY
LONG LIFE — LOW MAINTENANCE
SOLVES SLIDING LUBRICATION PROBLEMS

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Various types of BALL BUSHINGS *are made for shaft sizes from 1/8" to 4"... with small sizes available in Stainless Steel. Write for literature and name of our representative in your city.*

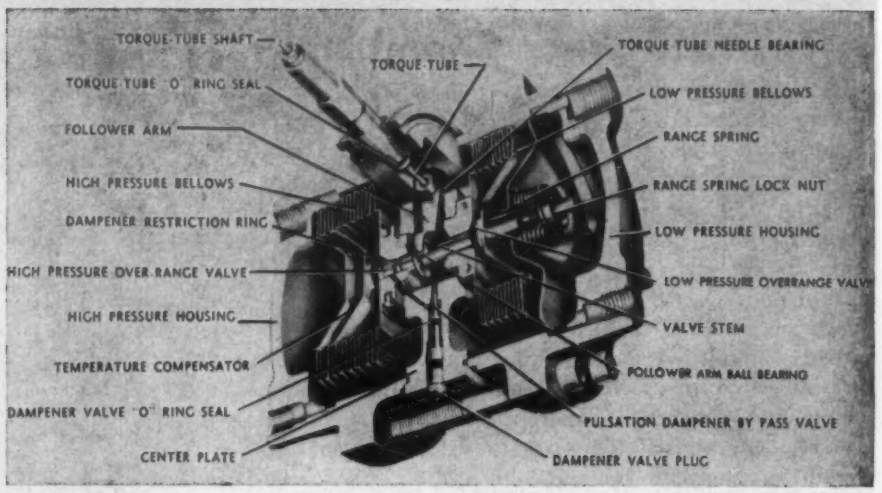
THOMSON INDUSTRIES, Inc.
Dept. D, MANHASSET, NEW YORK

Differential Pressure Sensor

Accurate measurement of flow in gases or liquids, highly important in modern missiles, submarines and aircraft is dependent on sensitive determinations of differential pressures arising from motion of the fluid through an orifice. A differential pressure sensor which combines sensitivity, stability of calibration and rugged, rupture-proof construction is being used in a wide range of indicating gages, recording meters and pressure data transmitters, switches and controllers. It is designated the Barton Model 224 Differential Pressure Unit.

The Differential Pressure Unit is composed of a rupture-proof bellows unit assembly and a pair of pressure housings that enclose opposite sides of the assembly (Fig. 1).

The Bellows Unit Assembly consists of a pair of bellows, a center plate, over-range valves, a temperature compensator, a torque tube assembly and a range spring assembly. The two flexible metal bellows are mounted on opposite ends of a center plate. The outer ends of the bellows are sealed and they are rigidly connected internally by a stem passing through an annular hole in the center plate. Opposed valves located on the connecting stem are arranged to seal against corresponding valve seats on the center plate at predetermined positions of the stem. The interior of the bellows and center plate are completely filled and sealed with a clean, non-corrosive, low freezing-point liquid. Expansion of the fill liquid due to changes in temperature are accommodated and compensated by a free floating bellows section on the high pressure side of the bellows unit.



DIFFERENTIAL pressure arising from motion of fluid torque tube shaft of Barton through orifice actuates Model 224 meter body.

The torque tube assembly transmits motions of the bellows to the exterior of the unit. It also furnishes most of the balancing force at the lower ranges of pressure. However, in the upper ranges, the range springs incorporated within the bellows assembly furnish most of the balancing force.

In operation, the bellows move in proportion to the difference in pressure applied across the bellows unit assembly, which motion is translated into rotary motion of the torque-tube shaft. If the pressure in either direction should exceed the pressure range of the instrument, one of the valves on the center stem will seal against its seat, trapping the enclosed liquid which supports the bellows assembly against rupture regardless of the magnitude of over-pressure applied. (*From 8-page bulletin, "Meter Body 224", Barton Instrument Corporation, Monterey Park, Calif.*)

FOR THIS LITERATURE CIRCLE 117 ON READER-SERVICE CARD

Training is Answer to Engineer Shortage

An increasing shortage of qualified electromechanical engineers has been forecast for the coming five years by the US Office of Education.

More efficient methods of teaching techniques of Control Systems Engineering at the college level to bridge the gap between servo theory and practical applications have been suggested as one method of minimizing the effects of this shortage. Supplemental training of young engineers and the upgrading of engineers who lack servo control techniques by industry are also measures which are profitable for many organizations who have an urgent need for these engineering skills.

The vehicle for streamlined instruction in servo control techniques is available in Servolab*, a complete servosystems laboratory. All essential simulation and analysis equipment are combined into one modular system, in which fully compatible modules and components are supplied within an ever-expandible framework (See Figure).

Servolab includes the following elements: 1) Power Supply unit, which can simultaneously supply up to six working stations serving 18 students, with all regulated plate, cathode and filament voltages; 2) Servoboard Educational breadboarding kit, providing a wide array of precision hardware to simulate the mechanical portion of the system, plus devices to incorporate the electrical components; 3) The Synthesizer which comprises five basic electric components—servo-amplifier, signal amplifier, modulator, demodulator, and corrective network; and 4) the Servoscope* Analyzer-Indicator Unit.

Courses ranging in complexity form the basic to postgraduate levels can be taught easily in minimum time and dollar cost. Furthermore research projects which would normally be outside the capability of the average company laboratory can now be fully encompassed with ease. Realistic laboratory experience, freed from the usual error-prone, time-consuming "jury-rigs", includes the following partial curricular listing.

*Copyright, Servo Corporation of America

COMPLETE SERVO LABORATORY for instruction and research is available in the SERVOLAB, consisting of (left to right) Servo Synthesizer, Servoboard breadboarding kit, Servoscope Analyzer-Indicator Unit, and Power Supply Unit.

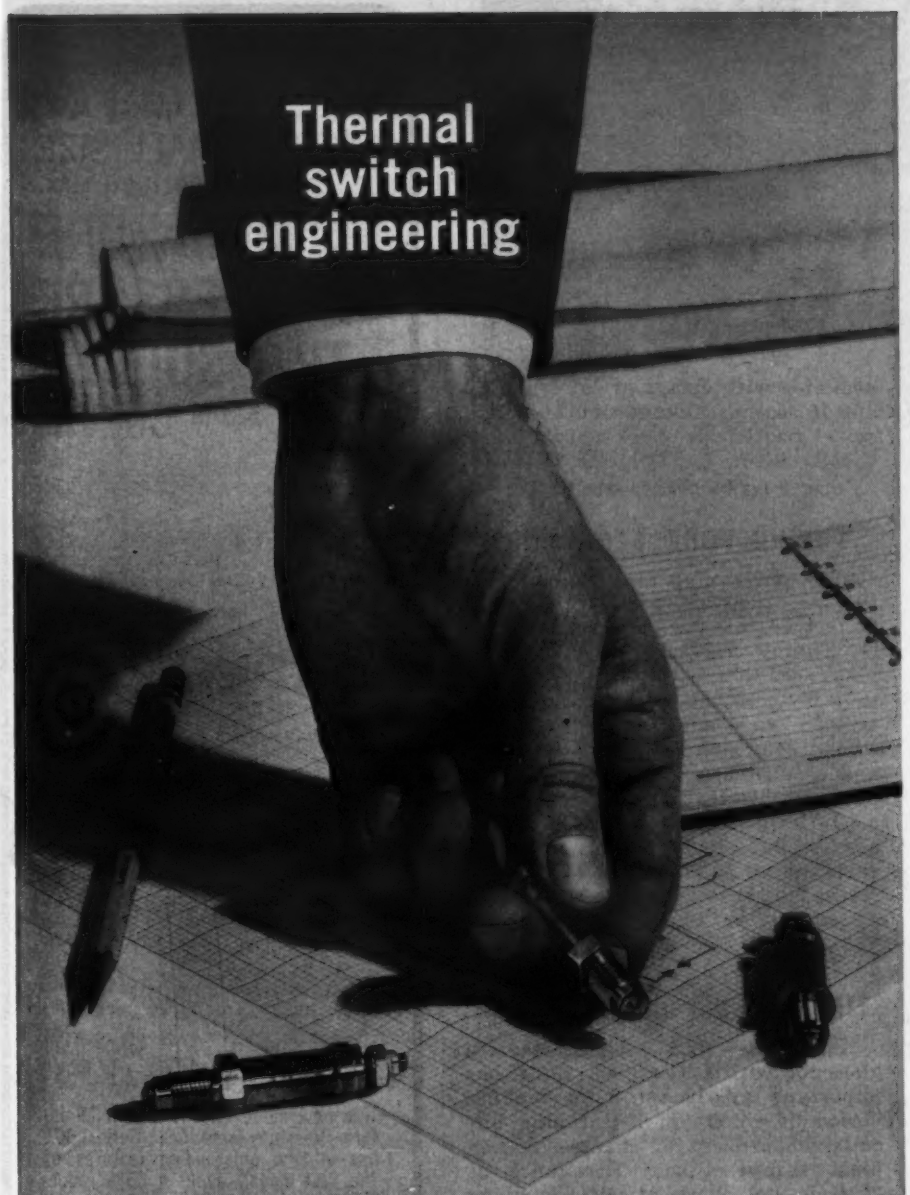
A. Trial-and-error design procedure including: linear models for physical systems, block diagrams, Laplace transforms, stability criteria, transient response, frequency response, performance indices, and compensation schemes. Analytical design procedure including: Parameter adjustment for minimum integral-square error, stochastic signals, variational procedure, minimization of mean-square error for fixed and free configurations, use of constraints, effects of fixed elements, saturable elements, and bandwidth limitation.

B. A study of servomechanism control and feedback amplifiers. The study includes both the transient response and frequency spectrum types of analysis as applied to the stability problem. Applications to practical feedback systems will be analyzed.

C. Differential equations of dynamical systems, analogues, linearization techniques, block-diagram representation, concept of transfer function, classical servomechanisms, transient analysis and synthesis, frequency spectrum analysis and synthesis, stability criteria, transfer loci, compensaion mehods, use of inverse plane, Bode plot, straight-line approximations, gain-phase relationships, Nichols chart.

D. Characteristic behavior of open- and closed-loop, linear, time-invariant systems. System analysis and simulation with an analogue computer. System analysis and synthesis using Bode digarams, Nichols charts, and Evans root locus methods. *From 8-page Special Report, "A New Concept for Teaching Servosystems," Servo Corporation of America, 111 New South Rd., Hicksville, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 118 ON READER-SERVICE CARD



"TIP TEMPERATURE" RESPONSE SWITCH FROM CPI RESEARCH

This is a new precision thermal switch designed to act as a warning device in controlling temperatures in aircraft generators. But that is only part of the story. This CPI switch responds to tip temperatures rather than shell temperatures. For that reason it's called the "Tip-Stat". It now joins the growing CPI family of high quality, custom, precision thermal switches.

There's a good chance that this switch or a modification of it can solve your thermal control problems. If not, CPI engineers can create a new switch that does. In either event, why not tell us about your thermal control problem now?

This hermetically sealed switch has spring loaded inner cartridge, can be "bottomed" in hole under considerable tip pressure; calibration range is −20F to 550F; safe momentary overshoot to 600F; reaction time, less than 0.5 seconds. Mention "Tip-Stat" when inquiring.

CPI

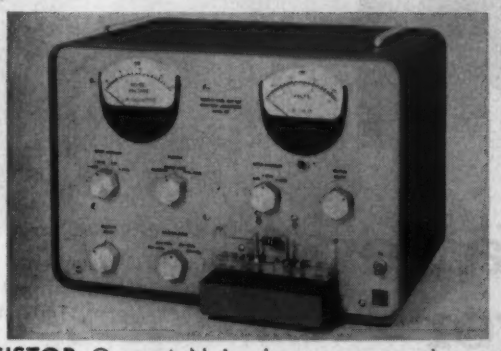
CONTROL PRODUCTS, INC.

311 Sussex Street, Harrison, N. J.

CIRCLE 38 ON READER-SERVICE CARD

Resistor Current Noise is Measurable Parameter

Resistor current noise in terms of μv/volt in a decade, a new figure-of-merit recommended by the National Bureau of Standards and the International Electrotechnical Commission, can now be measured by a new test set developed by Quan-Tech Laboratories, Inc., Boonton, N. J. The new development will provide design and development engineers with a new tool to speed the measurement of circuit and component parameters and to provide greater insight into future behavior of components during actual operation.



RESISTOR Current Noise is new parameter measured by Model 315 Test Set, now being evaluated by National Bureau of Standards as a primary standard.

Designated the Model 315, the test set provides the designer with a measure of the efficiency with which the resistor under test converts applied dc power to available noise power. This index, measured in accordance with NBS and IEC recommendations, will provide a reference to determine the effect of resistors which may be utilized in critical electronic circuits.

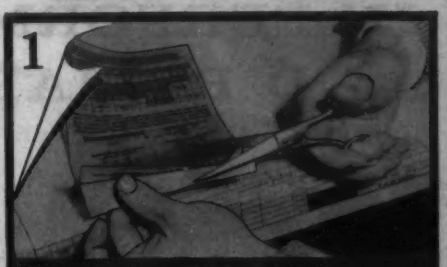
In low-level audio and low frequency circuits, resistors may contribute a large proportion of masking noise and interference which obscures vital signal information. This noise can be generated by molecular thermal motion, termed "thermal noise", or by direct current passing through granular-type resistors. Because current noise is dependent upon many factors, it is difficult to predict its value from physical constants. By determining the "noise quality" of resistors in terms of a quality index, the circuit designer is furnished with a method for more accurately predicting circuit functions under extreme conditions.

Designed to test resistors of all types from 100 ohms to 22 megohms, the Model 315 measures noise voltages from 10^{-2} μv/root cycle to 10^{2} μv/root cycle for flat noise, over a 1000 cycle bandwidth. The frequency response of the meter is made flat over the 1 kc bandwidth by a passive 4-section modified Butterworth filter adjusted so that the response to a 1/f power spectrum is equal to the response of a flat power spectrum.

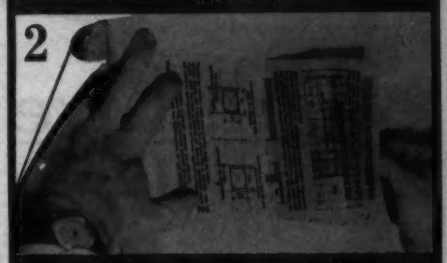
The detector is square law with a capacity for instantaneous response in excess of 10 db above full scale of the meter. Output voltages of 1 v rms for full scale ac output and from +1 v to +10 v dc for meter readings of 0 db to 20 db are available at the jack. These outputs are available for oscilloscope viewing, remote indications, or for semi-automatic testing.

FOR MORE INFORMATION CIRCLE 119 ON READER-SERVICE CARD

THIS IS THE CORRECT EASY WAY



PEEL
the STANPAT from its backing.



PLACE
the STANPAT into position on the tracing.

PRESS
into position . . . will not wrinkle or come off.

Don't chain your engineers to time-consuming routine on repetitive blueprint items . . . free them for more creative work and save countless hours of expensive drafting time with STANPAT.

STANPAT prints these items on tri-acetate sheets that are easily transferred to your tracings. No special equipment required . . . reproductions come out sharp and clear . . . and STANPAT is incredibly inexpensive.

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Address_____

CIRCLE 39 ON READER-SERVICE CARD

BIG

IN PERFORMANCE AND RELIABILITY

TINY IN SIZE

V LINE

Miniature Vane Axial Blower

This is the newest development in EAD's growing family of "V-LINE" Vane Axial Blowers. Maximum air delivery plus top efficiency (watts in against air out) in an extremely compact package — just 1.5" in total length, less than 2" in diameter. The unique mechanical and aerodynamic design incorporates EAD's highly-reliable 1"-diameter motor for highest fan speeds and life in excess of 1000 hours at 125°C. In addition to 2-pole characteristics listed, there are 4 and 6-pole designs and models for operation from 1600-cycle and variable frequency power sources. Meets MIL-E-5272A, MIL-E-5400B, other specifications. Write for complete data on this and other "V-Line" models.

TYPICAL CHARACTERISTICS

- 115 volts, 400 cycles single or three phase
- 19,000 rpm nominal
- 65 CFM at 0" SP
- 35 CFM at 2.3" SP
- 37-40 Watts
- 1.5" total length 1.990" housing dia.
- Available with:
  1. Leads
  2. Terminals on mounting flange
  3. Terminals on housing
- Weight, 4.3 oz.

EAD

Rotation is a science at

EASTERN AIR DEVICES, INC.

SUBSIDIARY OF NORBUTE CORPORATION

345 CENTRAL AVENUE, DOVER, NEW HAMPSHIRE

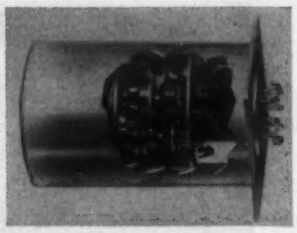
CIRCLE 40 ON READER-SERVICE CARD

MSD new products

TIMING

SEALED RECYCLING TIMER

New hermetically sealed, ruggedized Series F recycling timer actuates 1 to 7 cam-operated load switches in

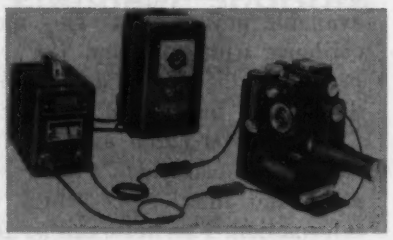


a pre-set ON-OFF sequence of from 1 second to 60 hour duration.—*Industrial Timer Corp.*, 1407 *McCarter Hgwy., Newark* 4, *N. J.*

CIRCLE 120 ON READER-SERVICE CARD

PHOTO-RECORD TIMERS

Electronic and electro-mechanical timers for use with ROBOT Electro-Automatic Photo-Recording system

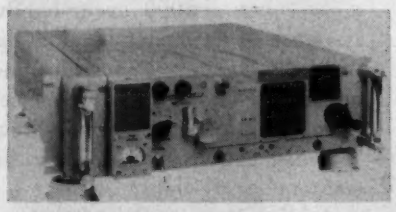


provide exposure intervals ranging from ¼ sec to 24 hrs for unattended photo registration over extended periods.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

CIRCLE 121 ON READER-SERVICE CARD

FREQUENCY SYNTHESIZER

New crystal frequency synthesizer, Model N317, produces over 64,000 discrete frequencies with a stability better than 1 x 10^{-8} part per day

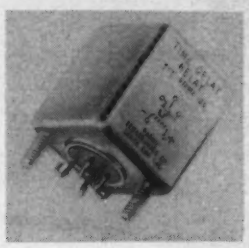


over the 2-34 mc range. All frequencies derived from single, highly stabilized crystal.—*Manson Laboratories, Inc., P. O. Box* 1214, *Stamford, Conn.*

CIRCLE 122 ON READER-SERVICE CARD

TIME DELAY RELAY

Low-cost subminiature Type BJSP-DT time delay relay designed primarily for ground support equipment is



available with delays of ½, 1, 2, 3, 5 and 10 seconds. Operates on 24 to 32 v dc.—*Parko Electronics Co.*, 2639 *S. La Cienga Blvd., Los Angeles* 34, *Calif.*

CIRCLE 123 ON READER-SERVICE CARD

TUNING FORK STANDARDS

Two new tuning fork standards in the 250—2000 cps range include Type 65 temperature compensated bi-metallic Tuning Fork in evacuated can, with accuracy within ±.002% from +15°C to +35°C without heater; and type 66 Frequency Standard which includes complete transistorized drive and amplifier circuitry in the same package with fork unit. Internal thermostatically controlled heater optionally available extends low frequency variation to −54° to 85°C range.—*Hathaway Instrument, Inc.*, 5800 *E. Jewell, Denver* 22, *Colo.*

CIRCLE 124 ON READER-SERVICE CARD

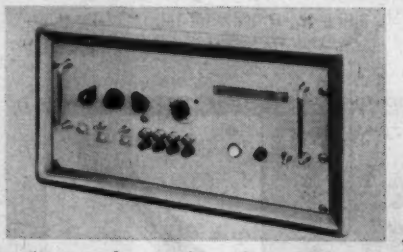
TIME CIRCUIT COMPENSATOR

New Type 21A7 Thermistor in glass rod with T/C of −3.1%/°C has important application in making period of electronic R-C timing circuits independent of changes in ambient temperature. Resistance at 25°C is 100 ohms, at 50°C is about 25 ohms.—*Victory Engineering Corp.*, 562 *Springfield Rd., Union, N. J.*

CIRCLE 125 ON READER-SERVICE CARD

TIME DELAY GENERATOR

New calibrated time delay unit provides delays from 0.1 to 10,000 μsec, for time measurements in delay line work and in computer develop-

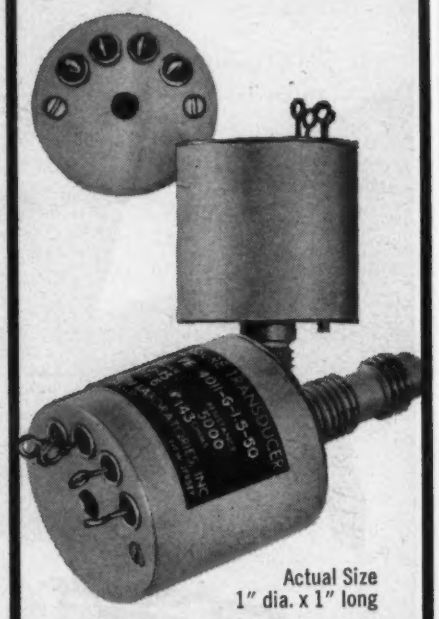


ment, e.g. in conjunction with computer clock, as a substitute in time circuits, and for computer checkout. —*BJ Electronics, Borg-Warner Corp.*, 3300 *Newport Blvd., Santa Anna, Calif.*

CIRCLE 126 ON READER-SERVICE CARD

LIGHT WEIGHT
ONE OUNCE MAX.
SMALL SIZE
ONE CUBIC INCH MAX.

MINIATURE PRESSURE TRANSDUCER FROM COLVIN



Actual Size
1" dia. x 1" long

This new model of the Colvin Miniature Pressure Transducer Series 401 has all the outstanding features of the first model — plus a 50% reduction in weight.

High vibration performance ±35G to 5,000 cps
Pressure ranges Absolute, differential and gage pressures 0-3 to 0-400 psi
Differential pressures ±3 to ±200 psi
Standard Nominal Potentiometer Resistances 400 to 10,000 ohms
Electrical Connection Pigmy receptacle or soldering terminals
Mounting Flange or bulkhead

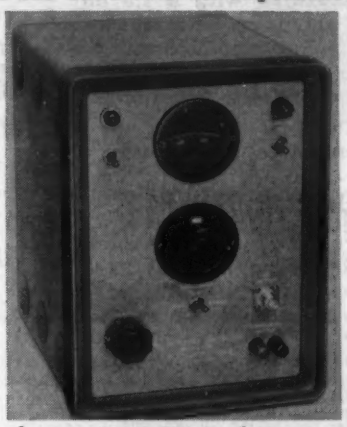
Write for complete information.

COLVIN LABORATORIES, INC.
364 Glenwood Avenue, East Orange, N. J.

CIRCLE 41 ON READER-SERVICE CARD

SWEEP/SIGNAL OSCILLATOR

New Type 9128 sweep- or manually tuned signal generator provides flat output power of 10 mw over 800-1400 mc band into an impedance of

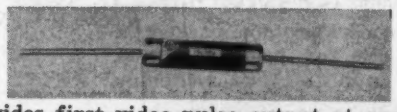


50 ohms, at a sweep frequency of 30 cps. Sweep to manual tuning change is by toggle switch. Oscillator tube is GE Type 7486 ceramic planar triode.—*CGS Laboratories Inc., Danbury Rd., Wilton, Conn.*

CIRCLE 127 ON READER-SERVICE CARD

ULTRA-MIN DELAY LINE

New magnetostrictive delay line Model FM-1080, for range marker calibration, is only 1.2" long. It pro-

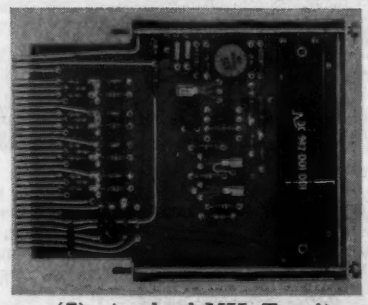


vides first video pulse output at precisely 3.050 μsec followed by 6.10 μsec echoes.—*Control Electronics Co., Inc., 10 Stepar Place, Huntington, L. I., N. Y.*

CIRCLE 128 ON READER-SERVICE CARD

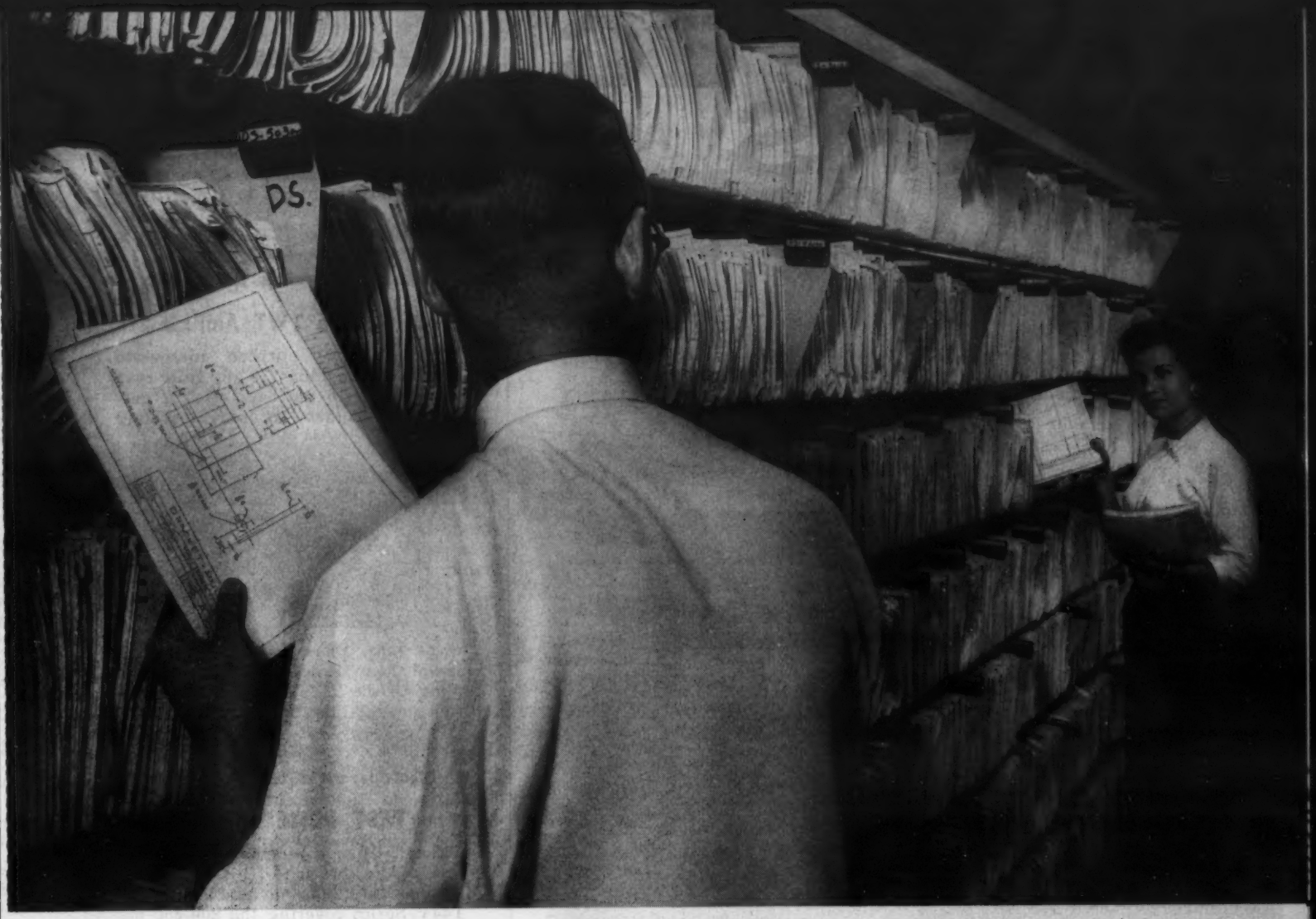
MILITARY DIGITAL MODULES

New MIL-T series dynamic, 1-mc, encapsulated digital modules meeting MIL-E-4159, MIL-E-5400 and MIL-E-16400 are functionally equivalent to T-PAC series but meet all environmental military requirements.



Seven (7) standard MIL-T units are: Logical Element LE-20 (illustrated), Storage Line SL-20, Delay Line (4 unit Delays) DP-20, Master Oscillator OC-20, Slave Clock SC-20, Synchronous Generator SG-20 and Static Flip-Flop FS-20.—*Computer Control Co., Inc., 983 Concord St., Framingham, Mass.*

CIRCLE 129 ON READER-SERVICE CARD



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You can save $50,000 or more a year by installing a stock-print system of engineering drawings. Cutler-Hammer Inc. of Milwaukee is achieving such an economy. So is Arma division, American Bosch Arma Corporation, Garden City, N. Y.

PUSH THE BUTTON *and copies flow!*

A stock-print system is a streamlined library of engineering drawings commonly in use. The library is unattended. Anyone who wants a drawing helps himself. There are no requisition forms, no waiting, no refiling. Prints are so inexpensive that engineers are urged to discard them after use.

What makes such efficiency . . . and such seeming extravagance . . . possible?

The answer is xerography and offset duplicating. Xerography is a clean, fast, dry, electrostatic copying process that within seconds reduces original drawings as large as 34"x44" onto inexpensive offset paper masters. From them, multiple copies are run off on an offset duplicator.

There is a wide range of XeroX® copying equipment for setting up an efficient stock-print system. Your reproduction needs determine the xerographic model best suited to you. All models—besides preparing offset paper masters—make copies on plain, unsensitized paper or translucent vellum for diazo-type reproduction.

All models—whether manual or automatic—enlarge, reduce, or copy size to size. They offer the fastest, most versatile, most economical way to get sharp, clear copies from original documents of all kinds or from microfilm.

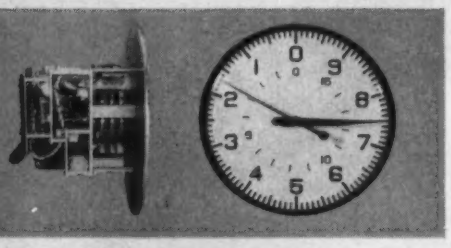
Write for proof-of-performance folders showing how companies of all sizes are speeding paperwork duplicating and saving thousands of dollars yearly by xerography. HALOID XEROX INC., 60-199X Haloid St., Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities. *Overseas:* Rank-Xerox Ltd., London.

HALOID XEROX

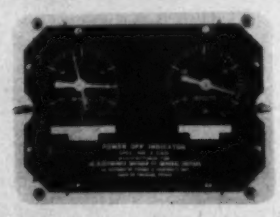
CIRCLE 42 ON READER-SERVICE CARD

MIL-SPEC TIMERS AND PICK-OFFS

Countdown Controllers accurately show split-second, continually corrected visual missile countdown sequence. Electrically synchronized with actual count.

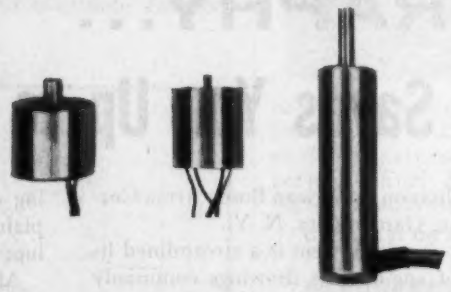


Elapsed Time Indicator gives visual check of power interruptions. Tied in with missile power supply from final assembly to launching. Records length of individual interruptions and total time off.



Transistorized Time Delay Relay (left) controls timing intervals from 50 milliseconds to 5 minutes. Made in 72 forms. **Hermetically Sealed Delay Timer** (right) provides fixed or adjustable time delay for repeat and reset cycle delay timing and sequencing for missiles or ground support equipment.

Atcotran Differential Transformers are electromechanical transducers for measuring linear motions. Three ATC mil-spec approved types, 6210-K (left) 6207-K (center) and 6203-K (right) give unprecedented reliability as displacement pick-offs for altimeters, pressure cells, servo feed-back signals, etc.



Send for your free Condensed Catalog "Automation Components and Control Systems"—today!

ATC can supply all kinds of differential transformers, timers, pick-offs and other related mil-spec components—designed and engineered to the most stringent specifications. Extensive research and development is constantly increasing reliability, design compactness and circuit simplicity to meet ever more exacting air and ground requirements.

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KING OF PRUSSIA, PENNSYLVANIA

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CIRCLE 43 ON READER-SERVICE CARD

TIMER COUNTER

New Model MFM-831 Megacycle Universal Timer-Counter using oven-regulated crystal, is said to be first all-transistor militarized high-speed frequency and time interval meter. Freq range is 10 cps to 1 mc; timer clocks from 3 μsec to 1 million seconds.—*Epsco, Inc., 275 Massachusetts Ave., Cambridge, Mass.*

CIRCLE 130 ON READER-SERVICE CARD

MICROWAVE TWT AMPLIFIER

New general purpose microwave amplifier providing 30 db gain over the 10.5 to 16 mc band uses a permanent magnet focused traveling

wave tube. Phase modulation is accomplished through capacitive coupling to the TWT helix, with amplitude modulation through the grid.—*Alfred Electronics, 897 Commercial St., Palo Alto, Calif.*

CIRCLE 131 ON READER-SERVICE CARD

TEST NOISE SOURCE

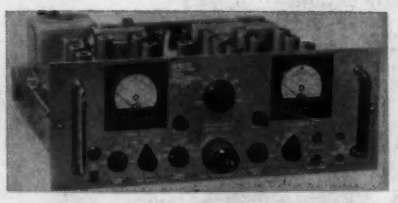
Coaxial gas tube noise sources for test and calibration of all microwave systems are now available in the T44V Series covering the 200-250 mc

range. Details on standard models and special versions up to 1000 mc are available on request.—*Tucor, Inc., 18 Marshall St., So. Norwalk, Conn.*

CIRCLE 132 ON READER-SERVICE CARD

PDM SIGNAL SIMULATOR

New Model 52 Signal Simulator generates pulse trains identical to video output of standard PDM tele-



metry receiver. Exceeds accuracy requirements of IRIG Document No. 103-56. Facilitates station set-up and check-out before missile firings.—*Instrument Corp. of Florida, P. O. Box 1226, Melborne, Fla.*

CIRCLE 133 ON READER-SERVICE CARD

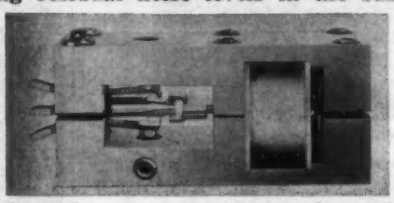
LOW NOISE DIODE

Very Low Noise silicon microwave mixer diode type 1N21F has a calculated overall receiver noise figure of 6.0 db max measured with a 1.5 db 30 mc IF amplifier. Supersedes 1N21C or 1N21E in applications requiring best S/N performance.—*Microwave Associates, Inc., Burlington, Mass.*

CIRCLE 134 ON READER-SERVICE CARD

LOW-NOISE CHOPPERS

Subminiature SPDT center-pivoted instrument chopper mechanisms having residual noise levels in the sub-

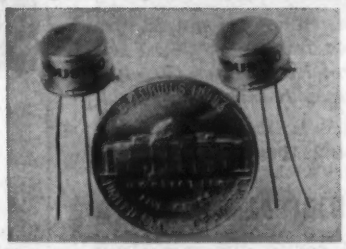


microvolt range are designed to exceed current MIL-specs for shock, vibration and temperature.—*James Electronics Inc., (Formerly James Vibrapowr Co.), 4050 N. Rockwell St., Chicago 18, Ill.*

CIRCLE 135 ON READER-SERVICE CARD

SILICON MESA TRANSISTORS

Types 2N696 and 2N697 Diffused Silicon Mesa Transistors packed in TO-5 case are for medium power, small-signal amplifier and switching

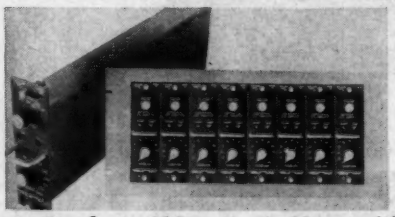


applications. Collector power dissipation at 25°C is 2 watts.—*Industro Transistor Corp., 35-10 36th Ave., Long Island City 6, N. Y.*

CIRCLE 136 ON READER-SERVICE CARD

DIFFERENTIAL DC AMPLIFIER

New chopper-stabilized Model 516 dc amplifier features a low noise of 14 microvolts rms over the entire bandwidth, dc to 25,000 cps. High



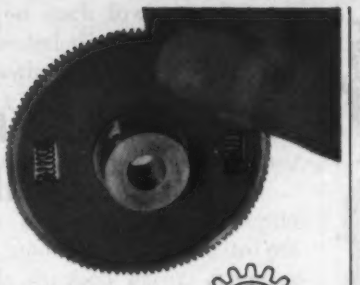
output of ± 100 ma at 10 v with continuously variable gain to 1000x makes it a general purpose instrument. Eight are shown in 19" rack.—*Allegany Inst. Co., Inc., 1091 Wills Mountain, Cumberland, Md.*

CIRCLE 137 ON READER-SERVICE CARD

Now Available!

PRECISION CLASS I & II anti-BACKLASH GEARS

Custom & Stock



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DORSETT

Qualified Telemetry System
MEETS MIL-E-5272
Environment

This is the Ryan Q-2C Firebee Drone's telemetering system . . . packaged by Dorsett engineers in a compact 8" x 13" x 5¼" configuration. These standard Dorsett telemetry components are used in the Model TMS-106 system: up to ten Model O-3 tube-type subcarrier oscillators, a Model PS-31 solid state power supply, an R-40 voltage regulator, a Model TR-4 PM transmitter, and a 25-watt A-25 amplifier.

For your telemetering requirement, whether missile, aircraft, drone, or balloon, DORSETT provides proved capabilities and facilities for the design and production of FM/FM, FM/PM, FM/FM/FM and PDM/FM systems and components. Geared to quantity production orders, DORSETT also provides close progressive technical liaison that assures customer satisfaction. Write today for specifications on proved-design DORSETT telemetry equipment.

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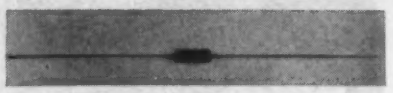
CIRCLE 45 ON READER-SERVICE CARD

SILICON DIODES

Military Computer diodes Types RD-212—RD-214 are said to recover to 200K ohms in 0.2 μsec and to have a typical capacitance of 1.5 μμfd. Also High back-resistance Silicon diodes,

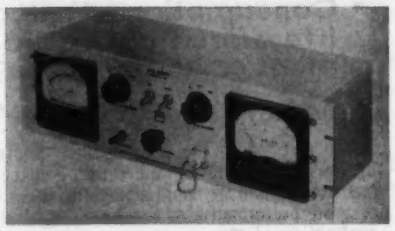


Types RD1356—1359 have unusually high back resistance to 50,000 megohms at 25°C. Forward conductance is 100 ma at +1 volt, with breakdown voltages to 200 v.—*Rheem Semiconductor Corp., 327 Moffett Blvd., Mountain View, Calif.*

CIRCLE 138 ON READER-SERVICE CARD

LOW-NOISE BIAS SUPPLY

New ISL Type 501 Bias Supply using batteries for extreme low noise provides 50, 100 and 500 volt ranges

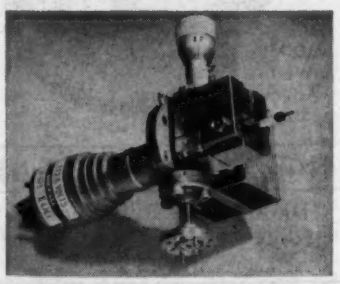


for accurate testing of photoconductors or thermistor bolometers.—*Infrared Standard Lab., 10555 Magnolia Ave., Riverside, Calif.*

CIRCLE 139 ON READER-SERVICE CARD

MILLIMETER KLYSTRON

Type QK673 is mechanically tuned reflex klystron oscillator with minimum output of 3 mw in the 88 to 92



kmc range. Output flange mates with standard UG387/U flange.—*Microwave and Power Tube Div., Raytheon Co., Waltham 54, Mass.*

CIRCLE 140 ON READER-SERVICE CARD

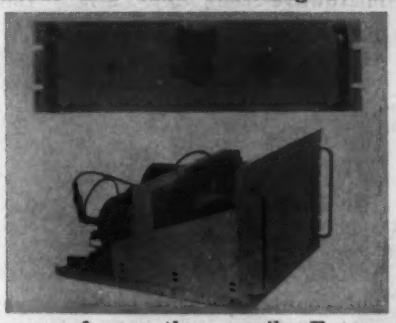
MICRO TOROID WINDING

Custom winding of small I.D. microminiature toroids to customer specifications in large quantities at high production rates is service offered. Also encapsulated microtoroids produced to order.—*Atlantis Electronics Corp., P.O. Box 451, Garland, Tex.*

CIRCLE 141 ON READER-SERVICE CARD

REMOTE SIGNAL SOURCE

New Model SS 305 remote tuned signal source for antenna pattern ranges is controlled in tuning, amplitude and band switching at dis-



tances of more than a mile. Frequencies from 50—2000 mc are calibrated to an accuracy of ±2.0% for a min output of 80 mw across 50 ohms.—*Scientific-Atlanta, Inc., 2162 Piedmont Rd., N. E., Atlanta 9, Ga.*

CIRCLE 142 ON READER-SERVICE CARD

BROADBAND KLYSTRONS

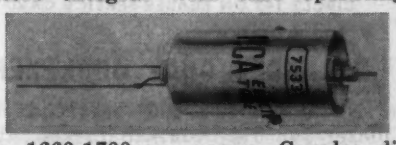
L-Band Type L-3283 Klystrons have gain and power characteristics essentially flat over 50 mc bandwidth

with min peak power of 2 mw. Linear phase shift versus frequency characteristic is useful in sophisticated radar systems.—*Electron Tube Div., Litton Industries, 960 Industrial Rd., San Carlos, Calif.*

CIRCLE 143 ON READER-SERVICE CARD

RADIOSONDE OSCILLATOR

New tunable oscillator triode on pencil type RCA-7533 has two resonators integral with tube operating



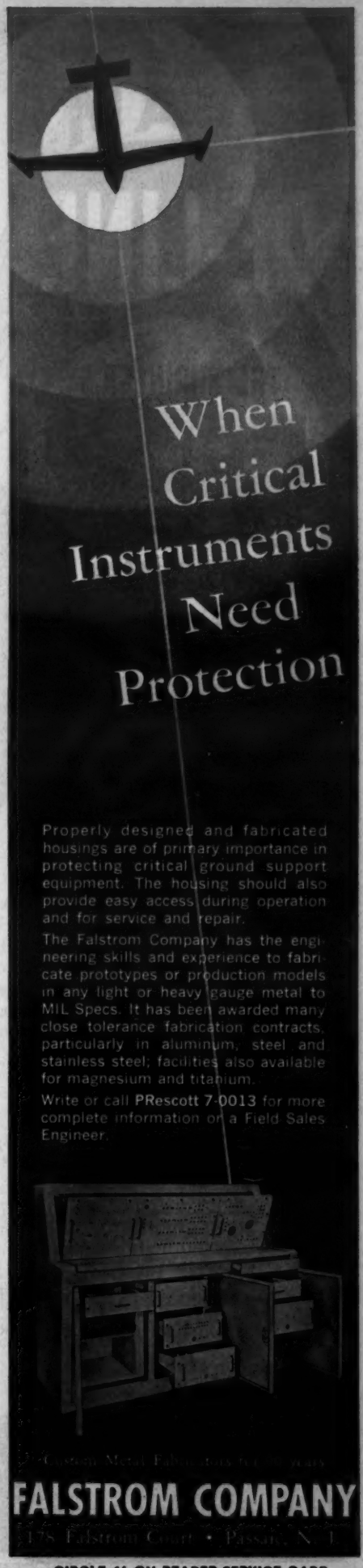
in 1660-1700 mc range. Couples directly to coaxial RF output of 250 mw at VSWR of 1.1.—*Electron Tube Div., RCA, Harrison, N. J.*

CIRCLE 144 ON READER-SERVICE CARD

BROADBAND VT VOLTMETER

New Model 104 high sensitivity VTVM for accurate measurement of ac voltages from 10 cps to 4 mc, and 1 mv to 330v operates from 115/230 v ac, 50 to 1000 cps power source. Designed for laboratory and field measurement of amplifier gain signal-to-noise, audio level, and network response measurements. Internal amplifier can be used separately as broadband high gain amplifier.—*Nuclear Electronics Corp., 2925 N. Broad St., Philadelphia 32, Pa.*

CIRCLE 145 ON READER-SERVICE CARD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Critical
Instruments
Need
Protection
Properly designed and fabricated housings are of primary importance in protecting critical ground support equipment. The housing should also provide easy access during operation and for service and repair.
The Falstrom Company has the engineering skills and experience to fabricate prototypes or production models in any light or heavy gauge metal to MIL Specs. It has been awarded many close tolerance fabrication contracts, particularly in aluminum, steel and stainless steel; facilities also available for magnesium and titanium.
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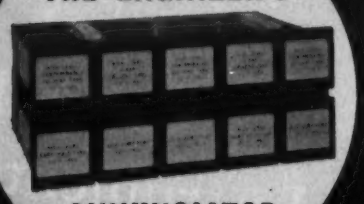
SCAM®

DE-LINE

THE ENGINEER'S



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GREATEST FLEXIBILITY IN THE FIELD

AVAILABLE IN MANY SEQUENCES

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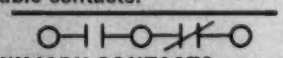
SIDE BY SIDE OR STACKED, DE-LINE modular design retains original custom appearance as system grows.

SAME PLUG-IN operates from normally open OR normally closed trouble contacts.



AUXILIARY CONTACTS N.O.–N.C. standard with most plug-ins.

SEQUENCE OPTION after installation by means of independent slide switch at each point.

DE-LINE plug-ins are self-policing. Systems are rugged and dependable.

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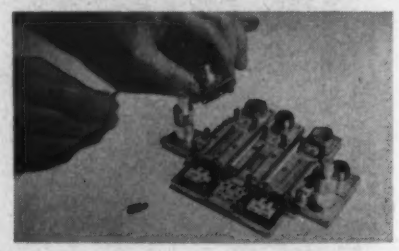
CIRCLE 47 ON READER-SERVICE CARD

L-BAND COMPONENTS

New TRI-PLATE Strip Transmission line modules operating in L-Band (1-2 kmc) have applications in microwave computer design, radar, radio astronomy, communications

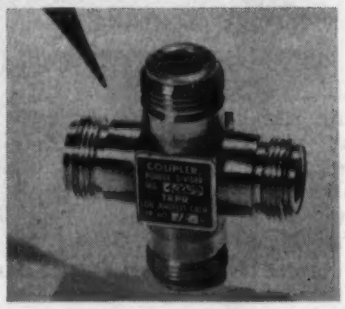


and counter measures. New hybrid rings, 3-db and 20-db couplers and 25ohm-to-50ohm transformers mate with existing broadband transitions, power dividers, crystal mounts and TRI-PLATE line bends, etc.—*Microwave Div., Sanders Associates, Inc., 95 Canal St., Nashua, N. H.*

CIRCLE 146 ON READER-SERVICE CARD

COAX POWER DIVIDER

Two- and three-way Power Dividers featuring broad bandwidth and low VSWR (under 1.3) weigh only 2.5

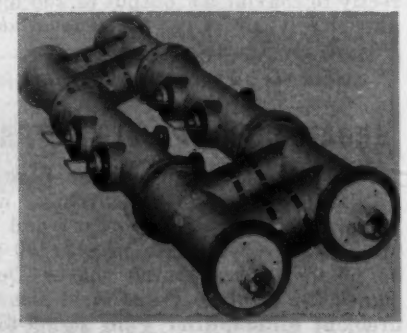


to 4 oz. Available in L, C, S and X bands; 50 ohm impedance.—*Transco Products, Inc., 12210 Nebraska Ave., West Los Angeles 25, Calif.*

CIRCLE 147 ON READER-SERVICE CARD

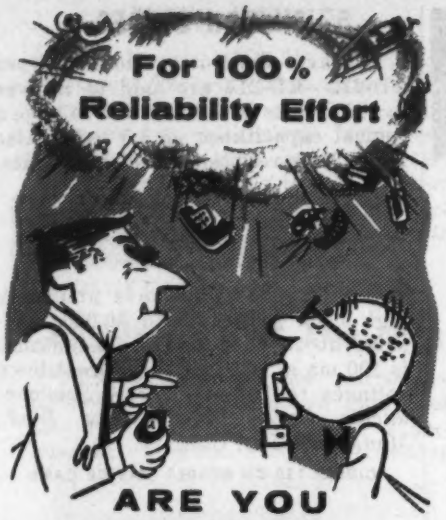
BALANCED COAX DUPLEXER

New type BL-595 balanced duplexer for 6⅛" coaxial line is rated at 10KW average power, consists of



two coaxial hybrids each with two cavities for plug-in cell-type TR tubes. Also available in 3⅛" and 1⅝" coax sizes.—*Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.*

CIRCLE 148 ON READER-SERVICE CARD



ARE YOU MEASURING . . .

- Actual life span of your equipment?
- Consumption of rated life of critical equipment or components?
- Mean-time-to failure?

You can reduce the odds against failure by constant monitoring and timely replacement of equipment approaching the end of assured performance . . . by thoughtful application of the . . .

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SUB-MINIATURE
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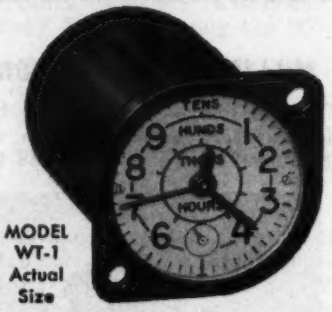

MODEL WT-1 Actual Size

1 1/16" O.D. x 1 15/16" 3 OZ.

10,000 Hour Total Readout
(Easily Read to Closest Hour)
400 CPS

Whether it's for reliability and life testing, design or system analysis, utilization studies . . . or to continuously monitor and log critical equipment or components . . . when you incorporate the Waltham WT-1 in your plans, you add that "measure of reliability" so important for military acceptance.

The WT-1 meets MIL-E-5272A and is available "FROM STOCK" Write Now for Bulletin 5001!

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Waltham 54, Massachusetts

CIRCLE 48 ON READER-SERVICE CARD

Slide Plate is New Technique in Digital Readout

The Industrial Electronics Engineers, Inc., developers of In-Line Digital Displays and the Bina-Dec-Decoder for conversion of binary outputs to decimal readout signals have announced a new type of readout component for the display of alpha numeric characters directly from binary coded decimal inputs (Fig. 1). It is also said to be characterized by single plane in-line presentation, no moving parts, minimum of maintenance, low-unit cost and long operating life.

The new unit requires no translating device and, in consequence, operates directly from any binary coded decimal or teletype code up to 6 bits without auxiliary relays or diodes. It also incorporates its own memory, continuing to display the last transmitted character until a new signal is received.

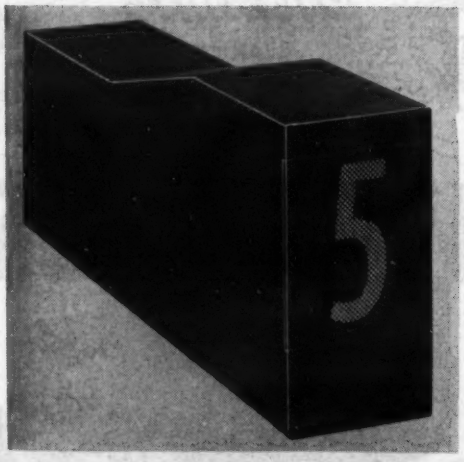


FIG. 1. DISPLAY UNIT operates directly from binary coded decimal or teletypecodes.

FIG. 2. SLIDE PLATE has built-in memory feature to hold display until release-command is received.

The Slide Plate works on such low signal power inputs that it can be connected directly to transistor or vacuum tube flip-flops without intermediate buffers or amplifiers, and without overloading the driving circuits. This means that it can be connected directly to computers and other electronic equipment, requiring less than 5 milliwatts of driving power.

The Slide Plate system memory feature operates as an interference-safe or noise-proof device to prevent the display of signals through error. After receiving and displaying a character the Slide Plate continues to display this character even though the signal is interrupted or changed to a different signal. This is because, in addition to the signal inputs to each Slide Plate there is a single "set-pulse" input. To command the Slide Plate to change to a new number and to store the new number, the "set-pulse" lead of the Slide Plate or bank of Slide Plates is impulsed. This commands the units to drop the old stored information and to accept, display and store the new signal information available to each Slide Plate at that moment.

Suitable check-back and verification circuits ensure that the signals have been properly accepted. Also, storage readout, which enables the information currently being displayed at some distant position can be read back into the source equipment, no matter how long before the displayed information was originally transmitted.

The Slide Plate's alphanumeric characters can include the alphabet, numerals and special characters which may be desired, all in the same unit. Combinations totalling 16, 40 and up to 64 separate characters on a single Slide Plate are available.

In addition to the super-sensitive version just described, a second self-setting version is designed to operate from relay closures where the signal power is sufficient to set the Slide Plate directly without the use of a set-pulse command. It will have all the other features previously described for Slide Plate units.

Applications

A bank of Slide Plate displays, together with common control equipment, can be used at widely separated airline ticket offices, hotels, etc., to show departure times for various flights. When connected to the central dispatcher's office over a single pair line, new information can be simultaneously displayed in each location which will remain on display until new information is received.

Other applications of immediate interest to the Military are status board displays for showing the disposition of units; aircraft ground control displays; airborne displays; ship and submarine control panel (Christmas Tree) displays.

Other digital systems developed in fifteen years of operation by the Industrial Electronic Engineers, Inc., with plant and office at 5528 Vineland Ave., No. Hollywood, Calif., include automatic warehouse order-handling machines, and an analog-digital converter for industrial weighing scales.

CIRCLE 149 ON READER-SERVICE CARD

COAX TERMINATIONS

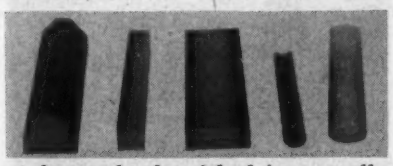
New RDL-3 series of wide-range, low-power, and low-VSWR terminations are available from stock in

HN, N, TNC, BNC, LC and LT connectors. Cover 0-4000 mc with VSWR of 1.05 or less up to 2 watts power.—*Radar Design Corp.*, 1004 *Pickard Drive, Syracuse* 11, *N. Y.*

CIRCLE 150 ON READER-SERVICE CARD

RARE EARTH & NOBLE METALS

New processed rods, wires, sheet and other shapes (as shown) in gold, platinum, silver and rare earth

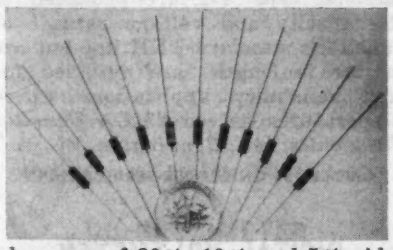


metals can be furnished in any alloy, and in vacuum-annealed and outgased states, to customer's specifications.—*Consolidated Reactive Metals*, Inc., 115 *Hoyt St., Mamaronek, N. Y.*

CIRCLE 151 ON READER-SERVICE CARD

SILICON ZENER DIODES

Glass-packaged quarter-watt zener diodes for computer and other compact applications offer 43 separate voltages from 6.8 through 200 v in



tolerances of 20%, 10% and 5%. Also available in series or parallel matched sets with tolerances to 1%.—*Motorola, Inc., Semiconductor Products Div., Dept NGD*, 5005 *E. McDowell Rd. Phoenix, Ariz.*

CIRCLE 152 ON READER-SERVICE CARD

PNP SWITCH TRANSISTOR

New PNP silicon high speed switching transistors provide wide range of betas from 15 to 50, also collector-to-emitter voltages from 15-to-50. are designated Types 2N1254 through 2N-1259, with operating temperatures from −65°C. to 160°C.—*Semiconductor Div., Hughes Aircraft Co., Newport Beach, Calif.*

CIRCLE 153 ON READER-SERVICE CARD

INFRA-RED
From infra-red transmitting elements . . . to alignment and emergency periscope for the Polaris missile . . .
Look what Bausch & Lomb can do for you with glass!
CLASSIFIED
from filters that eliminate unwanted radiation . . . to light-chopper reticles that put and keep IR-guided missiles on target . . .
from meltproof windshields and periscopes for high performance aircraft . . . to research and development of optical systems for space reconnaissance vehicles.
Let B&L competence with glass and glass-like materials help advance your system from design to the performance stage. Write for information on special items like these, or on research and development work.
And for data and specifications on our large stock of standard lenses, prisms and reflectors, ask for Cat. L-117.
Bausch & Lomb Optical Co., Contract Dept.
92104 Bausch St., Rochester 2, N. Y.
(Phone: LOcust 2-3000.)
BAUSCH & LOMB
SINCE 1853

CIRCLE 49 ON READER-SERVICE CARD

*A Partial Showing

Clifton Precision's size 8 rotary components have been tried and proven by customers over the past 4 years. More than 50,000 have been shipped. These are the most accurate and best tested (because they are use tested) size 8 rotary components on the market today.

1. Torque transmitter (26v. input) 2. Torque transmitter (115v. input) 3. Control transformer (lo Z) 4. Control transformer (hi Z) 5. Control transformer (very hi Z) 6. Torque receiver (26v. input) 7. Torque receiver (115v. input) 8. Torque differential (lo Z) 9. Torque differential (hi Z) 10. Electrical resolver (.5 t.r.) 11. Precision computing resolver (feedback winding) 12. Electrical resolver (1 t.r.) 13. Linear transformer (115v. input) 14. Linear transformer (26v. input) 15. Servo motor (1" length, .40 in-oz stall torque) 16. Motor generator (18v. input) 17. Servo motor (53/64" long) 18. Servo motor (35v. center tap) 19. Servo motor (26v. center tap) 20. Motor generator (26v. input) 21. Servo motor (.30-in-oz stall torque) 22. D.C. motor (14v. input) 23. D.C. motor (28v. input)

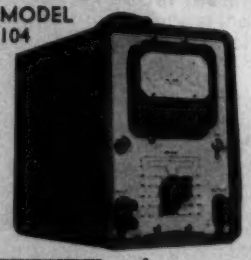
CLIFTON PRECISION PRODUCTS CO., INC.
CLIFTON HEIGHTS, PA.
Sales Office: 9014 W. Chester Pike, Upper Darby, Pa.—Hilltop 9-1200, TWX Flanders, Pa. 1122

cppc

CIRCLE 50 ON READER-SERVICE CARD

VACUUM TUBE VOLTMETER

MODEL 104



A HIGH SENSITIVITY, HIGH STABILITY INSTRUMENT . . . ACCURATELY MEASURES A.C. VOLTAGES, 10CPS-4MC, 0.001-300V.

LOOK AT THESE FEATURES: Guaranteed long-term high stability, accuracy and sensitivity combined with broad band frequency coverage. High impedance input. Freedom from switching transients. Simple, easy scale selection with front panel switch. Internal amplifier can be used separately as broad band high gain amplifier. Power source: 115/230 v, 50 to 1000 cps. Sensibly priced.

APPLICATIONS: Measurement of amplifier gain. Measurement of audio, supersonic, RD, video and TV voltages. Hum level. Audio level meter. Measurement of network response. Measures wide ranges of L and C (in conjunction with an oscillator).

NUCLEAR/ELECTRONICS CORPORATION

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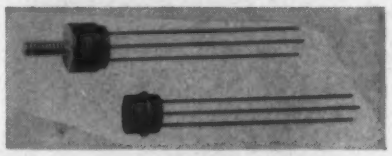
CIRCLE 51 ON READER-SERVICE CARD

MINI CONTROLLED RECTIFIERS

Power up to 300 watts can be controlled with new miniature silicon controlled rectifier using high alum-

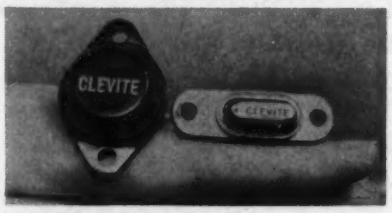


ina ceramic mounting for low thermal resistance. Complete characteristics available in bulletins C415-01 and D420-02.—*Solid State Products Co., One Pingree St., Salem, Mass.*

CIRCLE 154 ON READER-SERVICE CARD

SMALLER POWER TRANSISTOR

New Spacesaver power transistor, available for missile and computer applications, halves the size and weight of previous 3-amp power



transistors. Eight switching types have breakdown voltages of 40, 60, 80, and 100, dc gain ranges of 30-75 and 60-150, and frequency responses of 30 and 15 kc.—*Clevite Transistor Products, Waltham 54, Mass.*

CIRCLE 155 ON READER-SERVICE CARD

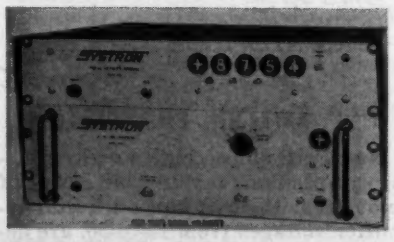
TANTALUM CAPACITORS

New miniaturized tantalum foil capacitors, type TH are produced in all capacity and voltage ratings of Tansitor's standard TEH line but are shorter in length; are designed for high reliability applications where temperatures exceed 85°C.—*Tansitor Electronics, Inc., Bennington, Vt.*

CIRCLE 156 ON READER-SERVICE CARD

DIGITAL VOLTMETER

New all-electronic digital voltmeter, Model 1231, features accuracies better than 0.05%, 20 msec conver-



sion, IN-LINE readout and automatic polarity for ranges from ±.0001 to 99.99 v. Applicable for automatic component testing.—*Systron Corp., 950 Galindo St., Concord, Calif.*

CIRCLE 157 ON READER-SERVICE CARD

Serendipity in Hi-Fi

Unexpected military applications resulting from a development originally intended only to provide the highest possible degree of realism in sound reproduction now promise to put the General Phones Corporation, 5711 Howe St., Pittsburgh 32, Pa., into the business of supplying a much-needed military item.

Their original development—a new type of variable-reluctance headphone intended to provide high-fidelity

FIG. 1. SONAR ECHO identification is enhanced by high fidelity characteristics of new headphones.

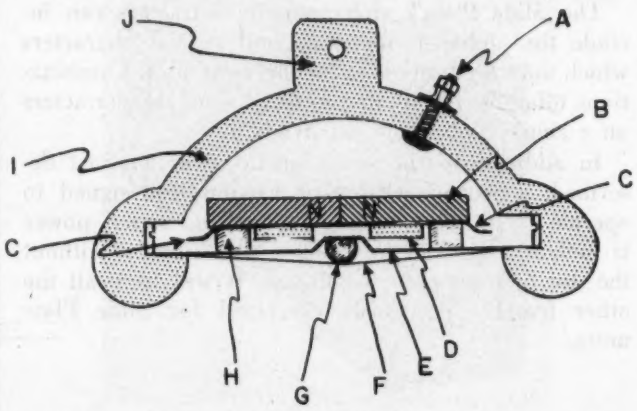


FIG. 2. VARIABLE RELUCTANCE phones utilize opposed Alnico magnets (B), flat coils (D), thin metallic disc (E), control cushions (H) and aluminum button (G) in molded rubber case (I).

stereophonic enjoyment of recorded music (Fig. 1)—was a surprisingly effective success, technically speaking. However, its high cost of production and an aversion to wearing headphones shared by most casual listeners held the demand to a few thousand sets.

However, flat audio response over the 20 to 16,000 cps range (down 4 db over 20 to 100,000 cps) in a comfortable headphone application evidently has other uses of more urgent importance than the ultimate in enjoyment of Bach, Brahms and Beethoven. Accurate identification of sonar echoes and underwater sounds, audio monitoring of telemetering and counter-measuser signals, and accelerated learning of foreign languages from recorded tapes and records are among the various military uses to which the new headphones are being applied.

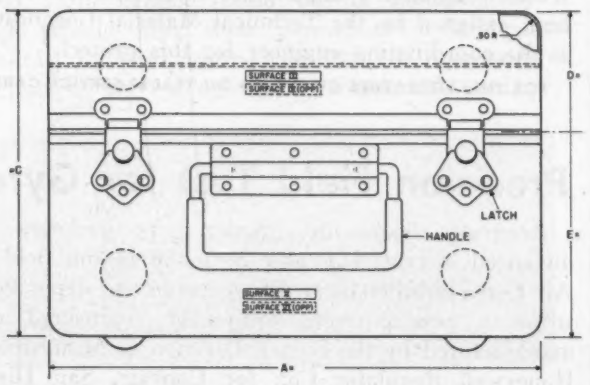
Strangely enough, reception of radio code and voice

signals is also enhanced by the true response characteristic of the "Hi-Fi" headphone. It has long been considered that the relatively narrow pass band of the standard military headphone, 300-3500 cps, serves to limit extraneous noise by narrowing the channel. However, although the new headphones admit all sounds within the range of human hearing, they are said to enable operators to read signals more accurately through interference than when using headphones conventionally designed for radio and intercommunication system service. Evidently the human ear has a surprising ability to discriminate over a wide range of frequencies if distortion is not also present.

Construction of the new headphones (Fig. 2) follows a new application of the variable reluctance principle. The nature of the magnetic circuit allows little space for windings, which limits the impedance to an inherently low range. Standard windings are 8 to 16 ohms, although 50 ohm phones are also supplied on special order. Opposed Alnico magnets, Bondeze coils and inside rubber mountings make the units capable of withstanding severe shock and acceleration tests. Hermetic sealing in a neoprene and rubber case also renders the units immune to weather and other environmental hazards, adding to their qualification for military use.

FOR THIS LITERATURE CIRCLE 158 ON READER-SERVICE CARD

Military Combination and Transit Cases



ELEVATION VIEW from reproducible sketch sheet to facilitate quotation meeting MIL-Specs and customer requirements for Military Cases.

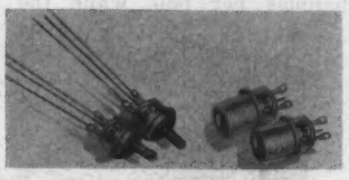
Submersion proof construction, hinged inner lid for storage of instruction books and cables, with continuous flange for mounting panels, are among features of metal cases meeting MIL-T-945, MIL-STD-108 and MIL-C-4150. Fabrication to specifications from aluminum, stainless steel, brass or cold-rolled steel, in all sizes to 30" x 36" x 15", also permits customer's choice in provisions for mounting, waterproofing, shockproofing, ventilating, hinging, locking, carrying, identifying and finishing.

(*From 4-page brochure, "Multi-Measure Metal Enclosures," plus six reproducible engineering sketches to facilitate quotation requests meeting MIL-Specs, MM Enclosures, Inc., Hicksville, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 159 ON READER-SERVICE CARD

PAIRED POWER TRANSISTORS

Complementary NPN-PNP power transistors in male and female industrial packages are said to exceed MIL-T-19500A requirements for con-

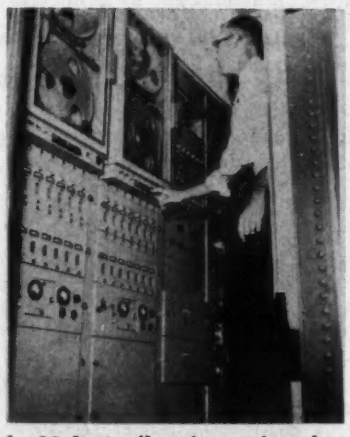


trol applications in guided missiles and rockets, Military audio output amplifiers, aircraft radio and intercoms, computers and servo-amplifiers.—*Semiconductor Operations CBS Electronics, Lowell, Mass.*

CIRLCE 160 ON READER-SERVICE CARD

SATELLITE DATA RECORDER

New Type 5-752 magnetic tape recorder/reproducers are being supplied for satellite tracking trailers built by Collins Radio Co., for ARPA.



Each 26-ft trailer is equipped with two DataTape recorder/ reproducers. Recording speeds range from 1⅞ ips through 60 ips with tape widths from ½" to 1".—*DataTape Div., of Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 161 ON READER-SERVICE CARD

DC RATIOMETER

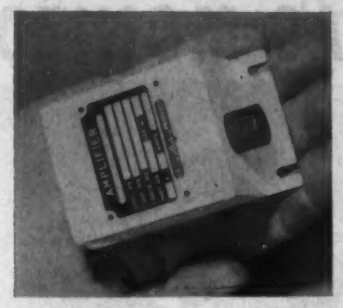
New servo indicator providing readings proportional to ratio of two dc signals can also indicate the ratio of

a single variable to its excitation source, thus providing measurements independent of source voltage changes.—*Instrumentation Div., North Atlantic Industries, Inc., Terminal Drive, Plainview, L. I., N. Y.*

CIRCLE 162 ON READER-SERVICE CARD

DC LOW-LEVEL AMPLIFIER

New low-level dc amplifier developed for MINUTEMAN missile

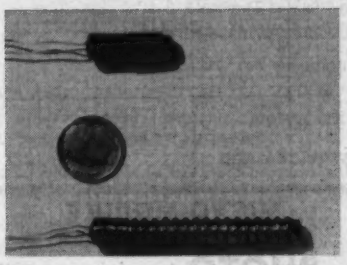


uses solid state chopper for converting dc-to-ac and back after amplification. Voltage gain is 50 to 200, linearity of 0.1% and output impedance of less than 100 ohms is achieved with less than 1.4 watts input.—*Avien, Inc.*, 58-15 *Northern Blvd., Woodside* 77, *N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

SQUIB MOTOR

Tiny Squib-actuated bellows motor provides 160 in-oz thrust over a 1" stroke within 1 msec. Actuator can be fired with 0.3 amp from 1.5 v

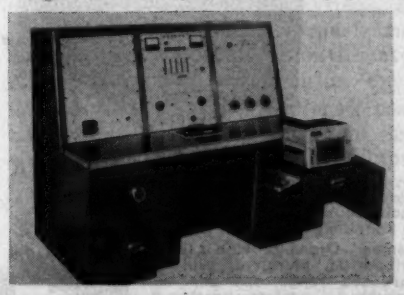


source, has a shelf life of years, functions properly over −65° to 165°F, and withstands 20,000 G shock and acceleration.—*Ordnance Materiel Dept., Atlas Powder Co., Wilmington* 99, *Del.*

CIRCLE 242 ON READER-SERVICE CARD

CONTROL TEST SET

Aircraft Generator Control panels are tested automatically by new T170 automatically programmed Digital Instrumentation System. Performs static regulator tests, overload trip point,



undervoltage trip time, differential protection, overcurrent protection, relay calibration and operation, step change frequency, forward and reverse diode tests.—*Avtron Manufacturing, Inc.*, 10409 *Meech Ave., Cleveland* 5, *Ohio.*

CIRCLE 243 ON READER-SERVICE CARD

ITEMCO
ENVIRONMENTAL TEST EQUIPMENT

ITEMCO Makes Chambers for:
VIBRATION
LOW TEMPERATURE
HIGH TEMPERATURE
ALTITUDE
HUMIDITY
SALT SPRAY
SAND and DUST
VACUUM OVENS
WALK-IN ROOMS

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(5 TO 5000 CPS FROM −120° TO +400° F AT 200,000 FT. ALTITUDE) (WITH AUTOMATIC CONTROLLING, PROGRAMMING AND RECORDING)
HIGH INTENSITY ACOUSTIC NOISE
(WITH DIRECT RECORDING)
HIGH-LOW+1200° F TO −120° F TEMPERATURES
(AT ALTITUDES TO 200,000 FEET)
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SUNSHINE • ROTARY ACCELERATION
SHIELDED ROOM FACILITIES
QUALIFIED PERSONNEL

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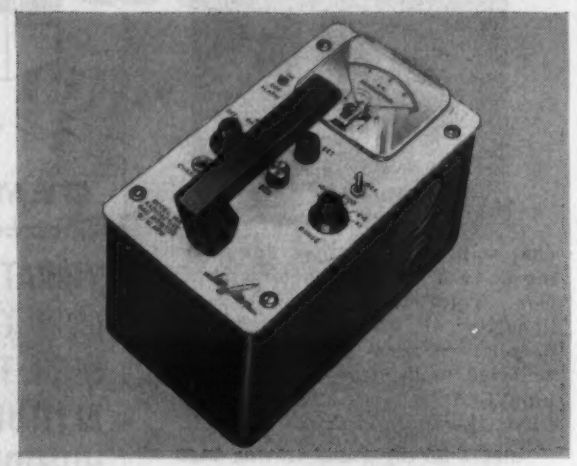
PORT WASHINGTON,
NEW YORK

CIRCLE 52 ON READER-SERVICE CARD

NEW PORTABLE
RADIOACTIVE GAS MONITOR

SENSITIVE TO:
TRITIUM (H^3)
RADON (Rn^{222})
KRYPTON 85 (Kr^{85})
CARBON 14 (C^{14})



Completely self-contained, the Land-Air Model 149 Radioactive Gas Monitor features audio alarm which may be set at any desirable threshold to furnish instant warning if radioactive gas concentration exceeds your predetermined limit. Weighing only 12 pounds, the model 149 requires no external power supply. It may be readily located in areas subject to contamination from Nuclear Reactors, Accelerators, Carbon 14 research, or Tracer research. A quickly attached flexible hose and probe increases the adaptability of this monitor to Health Physics Instrumentation, Area Monitoring, Air Pollution, and Leak Detection.

SPECIFICATIONS
SENSITIVITY—0-10^2, 0-10^3, 0-10^4, 0-10^5 Microcuries Per Cubic Meter
BATTERY LIFE—Electronics 500 Hours, Blower 15 Hours (rechargeable)
SOURCE—Push Button Operated, Less than 1 Microcurie Radium
AIRFLOW—2.5 C.F.M. Depending on Filters (Built-in Blower)
ELECTROSTATIC PRECIPITATOR—1 Kilo-volt Per Centimeter Gradient
ALARM—Preset at any desired Threshold
DESSICANT—Dries Electrometer Compartment

For complete information write to:

Land-Air INC. INSTRUMENT AND ELECTRONIC DIVISION
2133 Adams Avenue • San Leandro, California • Phone Lockhaven 9-5841
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electronic switch
flyback tester
oscilloscopes
probes
signal and sweep generators
tube testers
transistor tester
vacuum tube voltmeters
volt-ohm-milliammeters

HI-FI
stereo and monaural tuners
preamplifiers
power amplifiers
integrated amplifiers
speaker systems

HAM GEAR
cw transmitter
modulator-driver
grid dip meter

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HIGH RESOLUTION

"YALE" CAMERA

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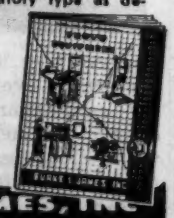
Diamond Ordnance Fuse Laboratory type as described in literature with increased range and convenience . . . micron range tolerances.

Write us with full details of your project. Delivery schedules now being processed.

Free 132 pg. Photo Equipment & Instrumentation Catalog. MSD 4/60

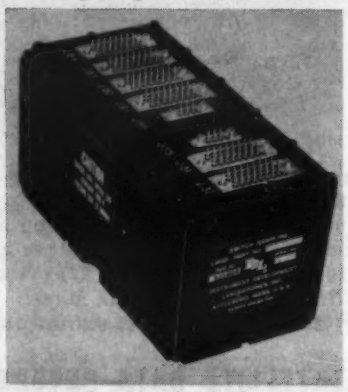


BURKE & JAMES, INC.
321 S. Wabash Chicago 4, Illinois

CIRCLE 55 ON READER-SERVICE CARD

FM/FM COMMUTATOR

New FM/FM Telemetering Commutator capable of sampling up to 180 make-before-break data channels at 5 rps has two poles sampling 30 channels per pole while the other

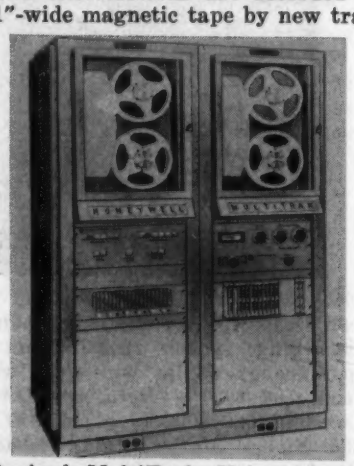


pair sample 60 channels per pole; weight is 3 lb 9 oz. Bulletin 500660 gives technical data and environmental conditions.—*Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.*

CIRCLE 163 ON READER-SERVICE CARD

MULTICHANNEL MONITOR

Up to 20 separate radio or telephone conversations are recorded on a 1"-wide magnetic tape by new tran-

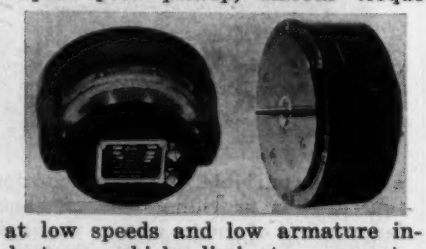


sistorized MultiTrak Voice Monitor, featuring dual recorders in monitoring air-ground and other emergency communications.—*Minneapolis-Honeywell Regulator Co., Industrial Systems Div., Beltsville, Md.*

CIRCLE 164 ON READER-SERVICE CARD

PRINTED CIRCUIT MOTOR

Flat printed circuit armature in new motor features low rotor inertia, rapid speed pickup, smooth torque

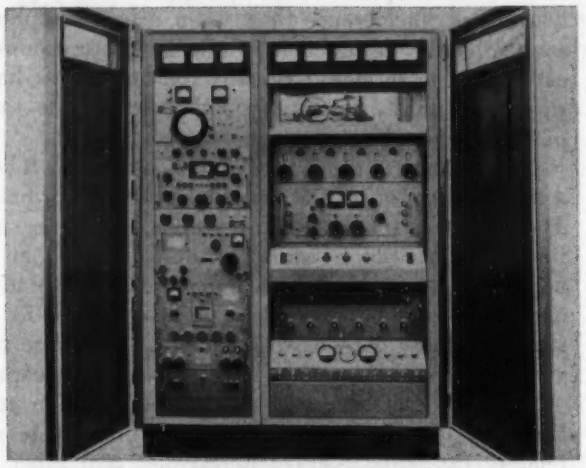


at low speeds and low armature inductance which eliminates commutator sparking.—*Photocircuits Corp., Glen Cove, N. Y.*

CIRCLE 165 ON READER-SERVICE CARD

Man-In-Space Communications

Tracking Stations for the MERCURY Man-in-Space project will be equipped with TMC Model GPT-10K (AN/FRT-39) 10 kw HF transmitters and associated receivers. Where added power is required, this transmitter will be coupled to a Model GPT-40KT Trans-



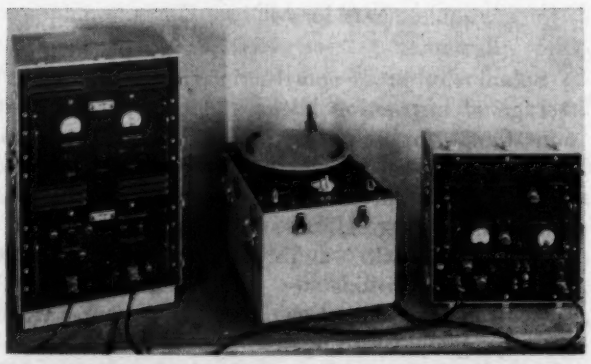
mitter, which provides a 40 kw output signal. Both models are products of the Technical Material Corp., Mamaroneck, N. Y.

The High Frequency radio equipments will serve to relay the information received by the tracking stations to a computing center. Prime contractor for the Project Mercury communications network is the Western Electric Company. Mr. Michael Yurko has been assigned by the Technical Material Corporation as the coordinating engineer for this project.

FOR THIS LITERATURE CIRCLE 166 ON READER-SERVICE CARD

Precision Field Test for Gyros

Accurate checks on complex gyro packages for advanced aircraft can now be made in the field by Air Force technicians at the squadron and depot level, using a new portable equipment engineered and manufactured by the Boston Division of Minneapolis-Honeywell Regulator Co., for Convair, San Diego, Calif., and the Air Force.



GYRO FIELD TEST SET components (left to right) are: Regulated Power Supply, Rate Table with variable mounting fixture, and Calibrator to provide precise measurements of system electronic performance.

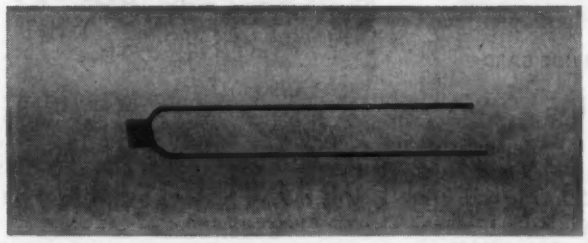
Field calibration of individual rate gyroscopes, rate gyro-amplifier-demodulator packages and amplifier-demodulators will be accomplished by the test set. The major components of the equipment are: 1) A calibrator providing precise measurement of system electronic parameters such as null voltage, output sensitivity, linearity, resolution, ac ripple, dc null and ac null; 2) a regulated power supply with an output of 115 v ±1½% (0 to full load), 400 cps ±1% with harmonic distortion of less than 2%, from an input of 1500 watts, 115v, 400 cps ±5%; and 3) a rate table with a range from 1° to 120°/second with a resolution of 0.03°/sec. Rate table fixture is designed to accommodate a wide range of gyros and gyro packages.

FOR THIS LITERATURE CIRCLE 167 ON READER-SERVICE CARD

"Pinhead" Capacitor for Encapsulation

Capacity values up to 100 in a package only twice the size of a pin head (See Figure) are a new development of Vitramon, Inc., Bridgeport, Conn. Designed particularly for use in encapsulated assemblies, and designated the "VK"-U series, they are designed for operation from −55°C to 150°C at 200 vdc without derating. Other members of this family offer values to 10,000 μμf with similar economy of space.

When properly encapsulated, the units demonstrate extreme reliability and ruggedness. Although protected from contamination during handling by a tough pliable film, their permanent environmental immunity under operating conditions is necessarily a function of the encapsulating compound used.



ACTUAL SIZE of 100 μμf "VK"-U type ceramic capacitor designed for application in encapsulated subassemblies.

Offered in capacity tolerances of ±10% and ±20%, the miniscule capacitor has a dielectric strength guaranteed to 400% of rated voltage, insulation resistance of the order of 10,000 ohmfarads at 25°C, and 35 ohmfarads at 150°C. Maximum capacitance change with temperature is typically ±10%. An interesting property of the hi-K ceramic dielectric is its improvement in dissipation factor at high temperature. DF, as measured at 1 kc, diminishes from max 2.5% at 25°C to less than 1.5% at 150°C.

All units have radial leads with standard 0.2" lead-to-lead spacing. They are also thermal shock-proofed and are more than equal to all stresses, strains and temperature extremes associated with conventional encapsulating materials and techniques.

FOR THIS LITERATURE CIRCLE 168 ON READER-SERVICE CARD

HI-SENSITIVITY CR TUBE

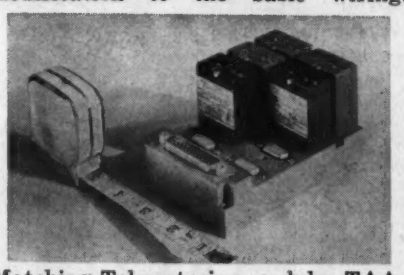
Highly sensitive 3-inch cathode-ray tube for oscilloscopes and other instruments is designated Type K-1951. Electrostatic focusing and de-

flection combined with 500 v acceleration voltage permits low-power compact circuitry with high light output and sensitive performance.—*Electronic Tube Div., Allen B. Du Mont Labs., Inc., Clifton, N. J.*

CIRCLE 169 ON READER-SERVICE CARD

TELE MODULE MOUNTS

New Mounting Units for subminiature modular telemetering components contain all necessary wiring and connectors to permit use of various plug-in components without modification to the basic wiring.

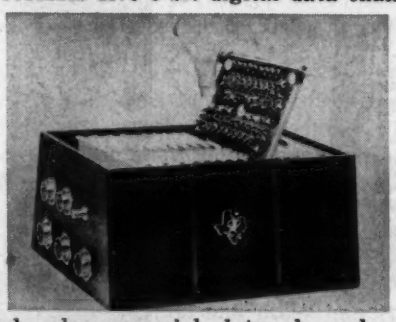


Matching Telemetering modules TAA-300 composite signal amplifier, TOE-300 subcarrier oscillator, TAA-301 voltage amplifier and TRE-voltage regulator may be installed singly or in combination to meet system requirements.—*Bendix-Pacific Div., Bendix Aviation Corp.*, 11600 *Sherman Way, No. Hollywood, Calif.*

CIRCLE 170 ON READER-SERVICE CARD

PCM TELEMETRY SYSTEM

New 25-lb solid state pulse code modulation system multiplexes and encodes 64 analog channels, and processes five 8-bit digital data chan-



nels plus a serial data channel at nominal bit rate of 200 kc. with a system accuracy of ±0.25%. Modular design permits quick modification to meet needs of any missile or space vehicle.—*Apparatus Div., Texas Instruments, Inc.*, 6000 *Lemmon Ave., Dallas 9, Tex.*

CIRCLE 171 ON READER-SERVICE CARD

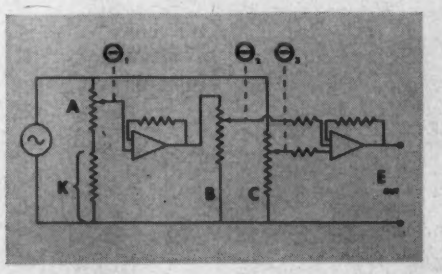
DESIGN IDEAS FOR ELECTRONIC ENGINEERS:

How to design better analog computing circuits with Vernistat* a. c. potentiometers

Analog computers typically use such components as potentiometers, resolvers, and linear synchros to relate shaft position to voltage. In most applications, to reduce the effect of loading error, high impedance circuits, and phase shift, a substantial amount of additional equipment, such as isolation amplifiers and auxiliary power supplies, is required. Size, weight, heat dissipation, and possibility of failure are thus greater than if loading error, phase shift, and high output impedance problems did not exist.

Typical of a class of equations which are incorporated into much analog computer circuitry is the relation

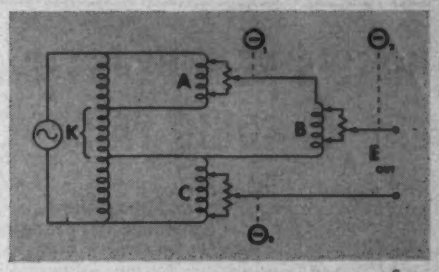
$E_{out} = [K + A(\theta_1)]\, B(\theta_2) + C(\theta_3)$.



ONE WAY TO SOLVE this relation is shown in this diagram of a conventional resistance potentiometer computing circuit. Such circuits, however, suffer from excessive phase shift, particularly at high frequencies.

Due to high potentiometer output impedances, the circuit requires an isolation amplifier in the multiplying channel, while summing resistors and a feedback amplifier are required in the addition section. Both of these amplifiers, as additional components, add a factor of unreliability and use more power, increasing the problem of heat dissipation.

A MORE EFFICIENT WAY TO SOLVE this equation is with Vernistat a.c. Potentiometers. The Vernistat is an ideal component for analog computer systems. Its combination of a tapped autotransformer and an interpolating potentiometer uniquely provide characteristics unobtainable with other types of shaft position-voltage devices. The Vernistat provides precise voltage division, high input impedance, low output impedance, and low phase shift. These characteristics directly relate to the design of improved computer circuits.



FOR EXAMPLE, in the computer circuit shown here, multiplication may be performed without the aid of an isolation amplifier, because of the Vernistat's high ratio of input to output impedance. Addition is accomplished by utilizing voltages of opposite phase in the two computing channels obtained by a tapped input transformer. By eliminating the amplifiers of the preceding circuit, a reduction of size, weight, heat rise, and power requirements is obtained. With fewer components required, there is an over-all increase in reliability.

IN SOLVING DESIGN PROBLEMS like these, Vernistat a.c. Potentiometers offer such major advantages as: low output impedance (as low as 40 ohms) with high input impedance (as high as 200,000 ohms)—high resolution (to 0.002%)—low phase shift (as low as 0.2 minutes)—and high terminal linearity (to 0.01%). Vernistats meet the requirements of MIL E 005272-B, and operate at 125°C without derating.

WRITE TODAY for full description and specifications on Vernistat a.c. Potentiometers, Adjustable Function Generators, and Variable Ratio Transformers.

*vernistat® — *a design concept that unites in one compact device the best features of the precision autotransformer and the multiturn potentiometer*

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Perkin-Elmer *Corporation*

CIRCLE 56 ON READER-SERVICE CARD

HOKE Flow Sheet

HOKE REPORTS ON FLUID CONTROL (1)

HOKE'S NEW PLASTIC STEM TIPS END CHRONIC FAILURE PROBLEM

Galling and scoring valve seats plagued valve users and manufacturers for years, until somebody thought of using plastic stem points. This idea worked well at low pressures, but when the pressure increased — poof! — the valve blew its tip. Up to now, this problem had continued to bother valve makers.

Fortunately, a die-hard Hoke engineer insisted he could put a permanent plastic tip on a high pressure valve. We gave him his head and he gave us a plastic-tipped valve-stem (using either Kel-F or Nylon). His unique design incorporates a crimped metal shell that grabs the plastic tip and *really* holds!

Not satisfied with this monumental accomplishment, he proceeded to tackle leak problems at the stem packing. He put an O-ring seal on the stem and compressed it with a newly-designed Nylon collar. The collar serves a dual role, for it also prevents grit and other foreign matter from chewing up the O-ring. Valves of this new design have performed successfully up to 3500 psi. Our die-hard engineer not only ended galling, but also seat leakage, stem leakage and wear problems — all at one swoop.

There's only one feature about this new development that worries us — since we do not expect replacements we may have designed ourselves right out of the valve business! We make these little dandies of either forged brass, bar stock or 316 Stainless, with ⅛" and ¼" male connections. Temperature limit is 400° F. For the complete story, write, wire, phone or we'll come see you.

WHAT GOES WITH WHAT?

This is a question engineers and chemists are constantly asking each other. Not that we want to do away with this healthy interplay at the water cooler, but we have put together a slide rule that answers all these questions. It lists 22 metals and materials and their degree of resistance to 247 corrosive agents.

Got yours? Write now while there are a few (thousand) left.

HOKE, INCORPORATED
13 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:
☐ Plastic Stem Tips ☐ FREE Corrosion Slide Rule ☐ Have a salesman call

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COMPANY_____

ADDRESS_____

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CIRCLE 57 ON READER-SERVICE CARD

COMPUTER/INDICATOR

Helicopter ground speed, and drift angle computer/indicator T8605-22N accepts two 400 cps analog voltages

from Doppler radar which represent heading axis and lateral axis speeds to compute output speeds to ± 1% of full scale, drift angles to ± 2°.—*Kearfott Div., General Precision Inc., Little Falls, N. J.*

CIRCLE 172 ON READER-SERVICE CARD

SUBCARRIER DISCRIMINATOR

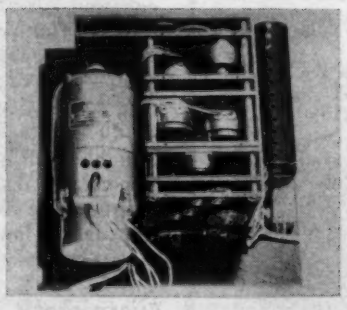
New Model D8001 FM discriminator converts FM subcarrier signals at standard IRIG center frequencies into dc outputs for operating most

recording instruments. Solid-state amplifier-limiter adjusts input sensitivity automatically for variations in signal level.—*Natel Engineering Co., 15922 Strathern St., Van Nuys, Calif.*

CIRCLE 173 ON READER-SERVICE CARD

QUIET MULTI-TRANSMISSION

New 15-speed Dynaco transmission unit using magnetic clutches to achieve exact and instantly-changed speeds from 3.3 to 7812 rpm can be



furnished to meet customer requirements, such as for oscillographs and recorders. More than half the gears in each Dynaco transmission are made of DuPont DELRIN to provide quiet longevity while transmitting up to ⅓ hp.—*Dynamic Gear Co., Inc., Dixon Ave., Amityville, L. I., N. Y.*

CIRCLE 174 ON READER-SERVICE CARD

MOTORIZED COMMUTATOR

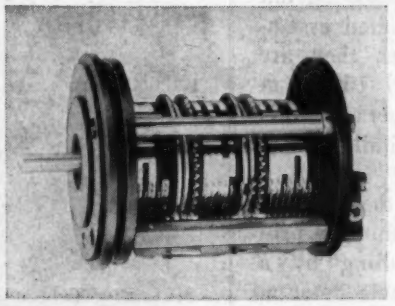
New line of motor-driven precision commutators cover speeds from 100 rpm to 3000 rpm, 5 to 50 segment commutators, and ac or dc motors

in standard voltages. Any number of gangs may be mounted or combined with high accuracy SuperCon Film pots.—*Computer Instruments Corp., 92 Madison Ave., Hempstead, N. Y.*

CIRCLE 175 ON READER-SERVICE CARD

SIZE 15 A-D CONVERTER

New miniature analog-to-digital converter couples directly to size 15 servo. 100 revolutions of input shaft

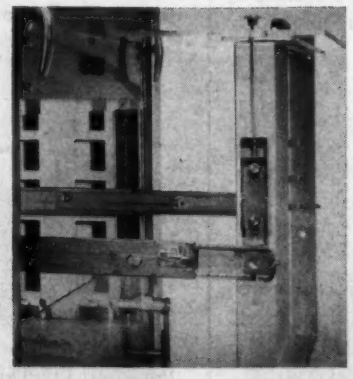


are required to complete the entire code from 0 to 999 at input speeds to 400 rpm.—*Courter Products Div., MEMCOR, 50 Frederick St., Huntington, Ind.*

CIRCLE 176 ON READER-SERVICE CARD

TILT-LOCK SLIDE

New Type 0-300 Detent Slide, supports loads up to 50 lbs in lengths from 12" to 24". Made of hard, cold-rolled steel, cadmium plated, then coated with Poxylube 75, the slides



withstand pressure loading over 50,000 psi at 25 fpm, meet JAN 100-hr salt spray test and are approved for military use.—*Chassis-Trak, Inc., 525 S. Webster Ave., Indianapolis 19, Indiana.*

CIRCLE 177 ON READER-SERVICE CARD

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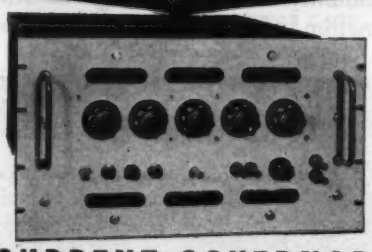

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nh NORTH HILLS ELECTRIC COMPANY, INC
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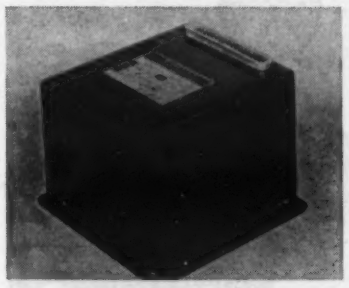
CIRCLE 59 ON READER-SERVICE CARD

ELECTRONIC COMMUTATOR

New solid-state electronic commutator for aircraft and missile multiplex telemetering systems feature load resistance from 5000 ohms

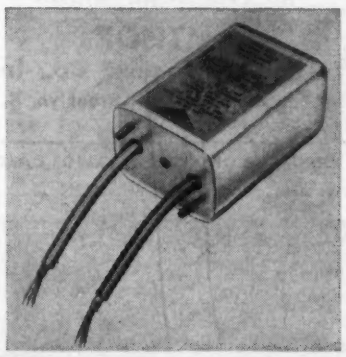


to 2.5 megohms, 5 to 10 ohm contact resistance, leakage levels less than 0.005 μamp at 5-v signal levels, in a volume of only 0.4 to 0.5 cu-in per channel.—*Kinetics Corp., 410 So. Cedros Ave., Solana Beach, Calif.*

CIRCLE 178 ON READER-SERVICE CARD

CHOPPER TRANSFORMER

New chopper input transformer Type G-24, for use over the 60-500 cps range uses new "Box" shielding

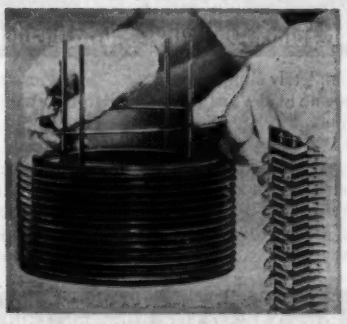


to reduce capacitive coupling to less than 0.05 μμf, has 1:1 ratio of 40,000 ohms CT to 40,000 ohms CT.—*Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.*

CIRCLE 179 ON READER-SERVICE CARD

EXPANDIBLE SLIP RINGS

New assembly design of flat hard silver slip rings permits addition of



rings when required, also provides maximum number of rings in shortest axial length for rated capacity.—*Breeze Corporations, Inc., 700 Liberty Ave., Union, N. J.*

CIRCLE 180 ON READER-SERVICE CARD

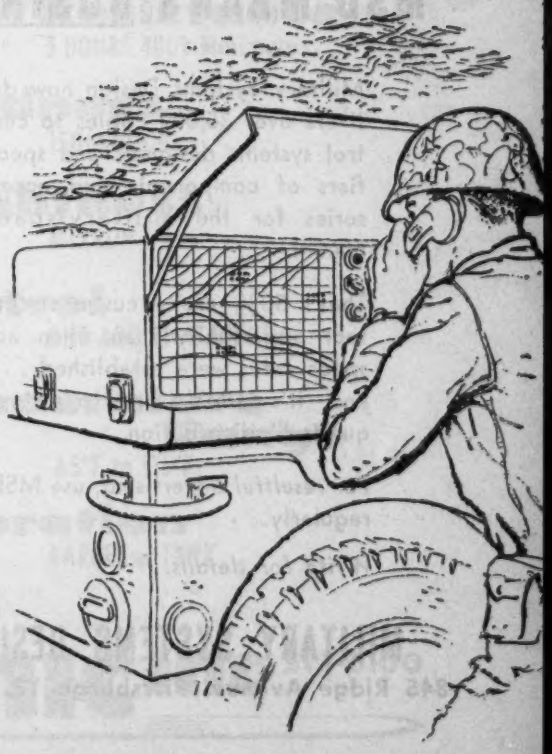
FOR THE COMBAT MARINE

Stromberg-Carlson-San Diego, in cooperation with the U.S. Marine Corps, has developed a revolutionary new tactical communications concept that will instantaneously transmit intelligence from forward observers and present a simultaneous tactical display to command. Known as BASIC (Battle Area Surveillance and Integrated Communications), it works this way:

Forward observers are equipped with small, hand-held digital message generators on which reports are "set up" through a series of switches. After checking the accuracy of his message, the observer sends the entire message in a short burst over his standard field communications equipment. The burst transmission doesn't interfere with simultaneous voice communication over the same radio channel.

Back at the command post, surveillance information is instantly displayed on a tactical map and simultaneously presented on typewritten cards showing target identity, location and other important information. Data may be fed directly to tactical computers for artillery fire control.

The same techniques and equipment used for the Marine Corps' BASIC concept are readily adaptable to a multitude of other military and commercial communications and display systems. For information about how BASIC techniques can solve your problems, contact Stromberg-Carlson-San Diego, Dept. A-41, 1895 Hancock Street, San Diego 12, California. Telephone CYpress 8-8331.



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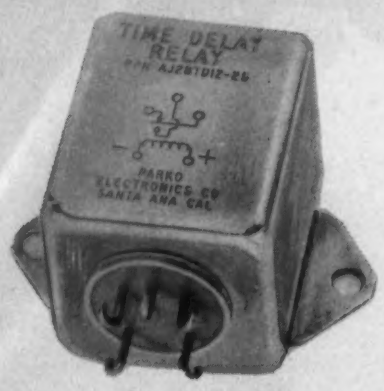

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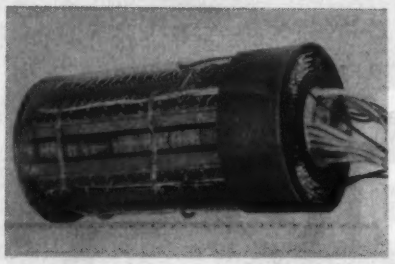
change; ripple 1 mv rms typical for 6-30 v dc, 0.5 amp output, 105-125 v, 60-400 cps input.—*Valor Instruments, Inc.*, 13214 *Crenshaw Blvd., Gardena, Calif.*

CIRCLE 181 ON READER-SERVICE CARD

ANTENNA SLIP RINGS

New standardized series of large antenna slip rings meeting MIL-STD-5400C minimize low S/N and

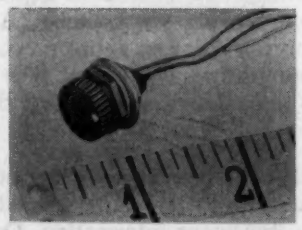


crosstalk levels, provide 50 to 500 plus circuits, current capacities to 2000 amps.—*Slip Ring Co. of America*, 3612 *West Jefferson Blvd., Los Angeles* 16, *Calif.*

CIRCLE 182 ON READER-SERVICE CARD

NO-SHAFT POT

New Cap-Pot utilizes knob as intergral part of the unit, eliminating shaft and bushing. Rating is 0.5 watts at 40°C derated linearly to 0



at 105°C. Type A to 5000 ohms max, tolerance ± 5% for life of 25,000 cycles min at 10 cycles/minute at rated power. Type B (Trimmer) to 10,000 ohms max., tolerance ± 10%, for life of 500 cycles min at 2 cycles/minute at rated power.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

CIRCLE 183 ON READER-SERVICE CARD

CUSTOM CONSOLES

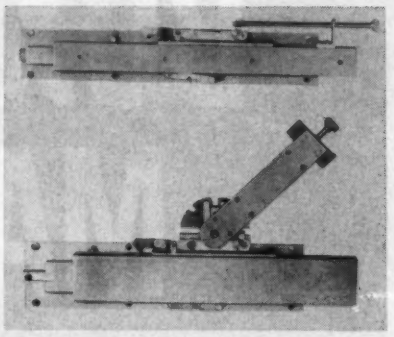
New "Stress Skin" technique permits forming greater part of cabinet shell of medium or large units

through modern presses to eliminate many joints, provide stronger radius corners, and higher strength/weight ratio in all traditional and "problem" metals.—*Falstrom Co.*, 304 *Falstrom Ct., Passaic, N. J.*

CIRCLE 184 ON READER-SERVICE CARD

CHASSIS SLIDE LOCK

New positive slide locks in closed, open and/or pivoted positions to remain locked until manually released.

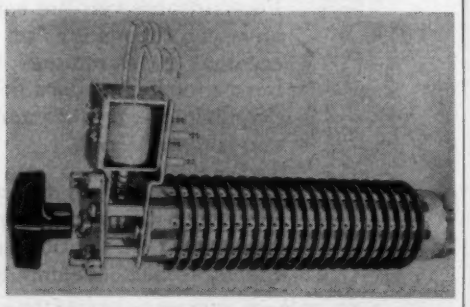


Holds even under shock and vibration testing. Weight capacities from 50 to 500 lbs per pair in lengths from 10" to 68".—*Grand Sliding Mechanisms, Inc.*, 2401 *W. Ohio St., Chicago* 12, *Ill.*

CIRCLE 185 ON READER-SERVICE CARD

SOLENOID SWITCH-LOCK

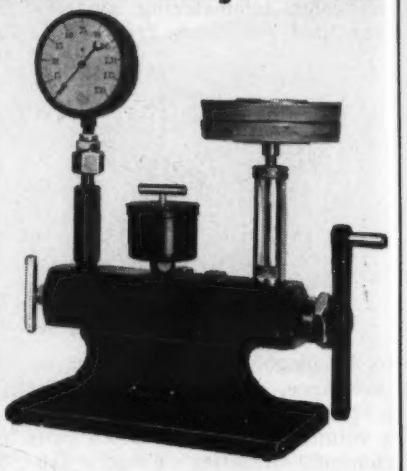
Solenoid locking for ESCO Jr multi-pole rotary switches to prevent unauthorized operation can be furnished to secure every position or



to lock only certain positions with others free for local control. Release can be either by energizing or de-energizing the solenoid.—*Electro Switch Corp., King Ave., Weymouth, Boston* 88, *Mass.*

CIRCLE 186 ON READER-SERVICE CARD

AMTHOR Dead Weight Pressure Gauge TESTER



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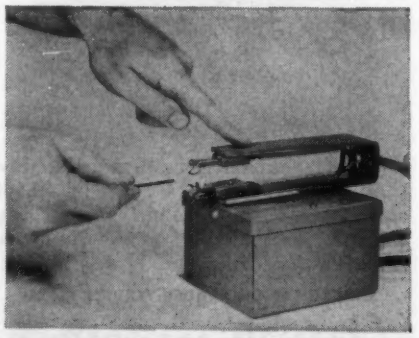

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New Rugged High-Speed
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Completely eliminates cut or nicked wire strands since no blades are used. Has High-Low heat control to strip both Teflon and lower-melting plastics. Strip any size wire without adjustment. Designed for high-speed production use. Use either as bench or hand tool. Simple to operate. Insert wire, clamp, then pull. Has adjustable stripping length stop. Sturdy long-life heating elements are easily replaceable. Heavy-duty power supply.

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Western Electronic Products Co.
655 Colman Street, Altadena, California

CIRCLE 64 ON READER-SERVICE CARD

VANE AXIAL FAN

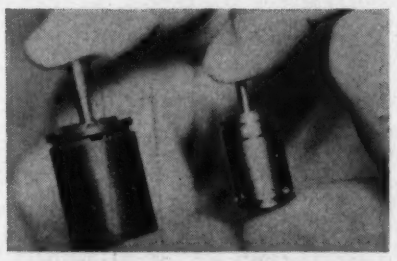
New Air-Marine Type E2543-200 fan, with housing dimensions only 4" diameter x 4½" long, delivers 200 cfm at ¾" Wg. It operates on

200v, 3-θ, 400 cps in ambients up to 85°C, for min 5000 hr life. Meets Mil-E-5400B and Mil-E-5422D.—*Air-Marine Motors, 368 Bayview Ave., Amityville, L. I., N. Y.*

CIRCLE 187 ON READER-SERVICE CARD

"SMALLEST" GEARHEAD

Tiny size 5 gearhead and speed reducer unit weighing only a few grams is only ½" in diameter, is

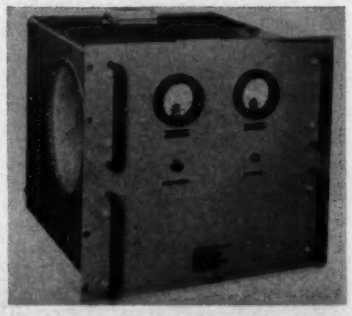


said to be capable of gear ratios from 10:1 to 2025:1. It will be used in future satellite electromechanical systems.—*Bowmar Instrument Corp., 8000 Bluffton Rd., Ft. Wayne, Ind.*

CIRCLE 188 ON READER-SERVICE CARD

MILITARIZED DC SUPPLY

New Model M-1324 DC Power Supply for Ground Radar featuring small size and long life meets all applicable Mil-Specs. Mag amp cir-



cuitry and transistorized pre-amp provide static line regulation of ±0.1% for ±10% line variations and static load regulation of ±0.1% no load to full load of 100 amp at 26.5 v. —*Perkin Engineering Corp., El Segundo, Calif.*

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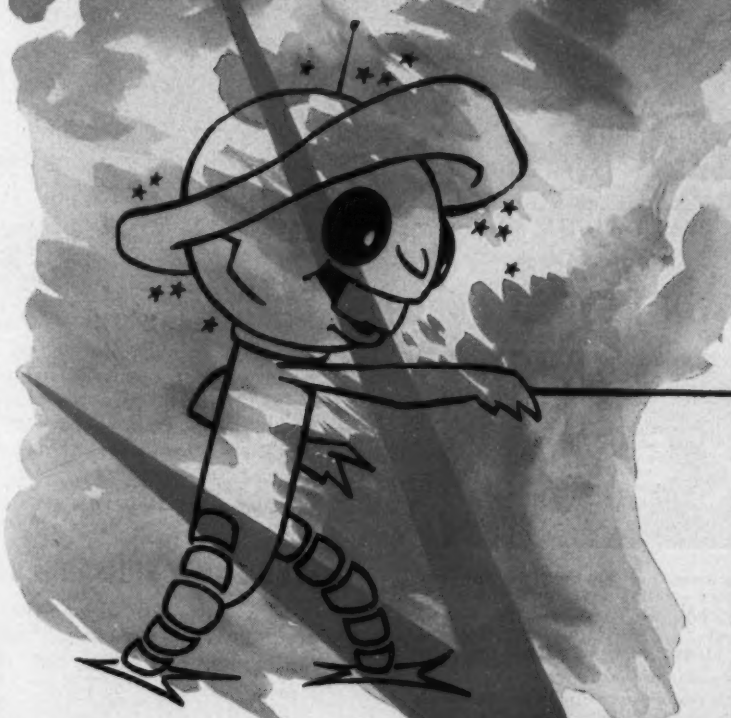

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Brightness
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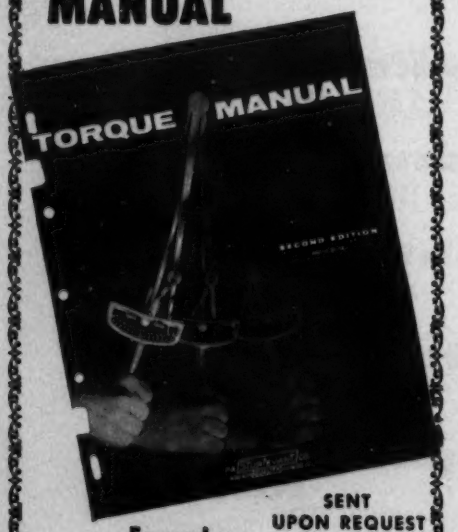

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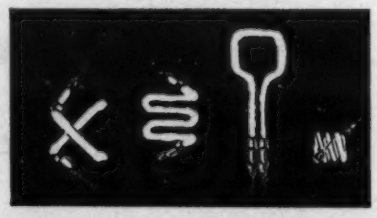

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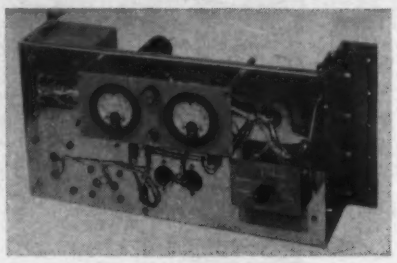
REGULATED POWER SUPPLY

New Model PS4023 transistorized regulated supply operating at input voltages of 105-125 v in either the 60 or 400 cps range, provides output



up to 400 ma load current at any voltage variable between 100 and 200 v, regulated to 0.03% for any combination of load and line conditions. Ripple and noise is less than 2.5 rms millivolts.—*Power Sources, Inc., Burlington, Mass.*

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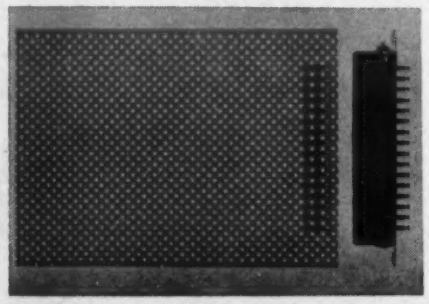
PROTOTYPE P-C BOARD

New Plugboards made of 1/16" thick epoxy paper material with 0.062" holes on alternate intersections of 0.1" grid have 16-pin Elco connector

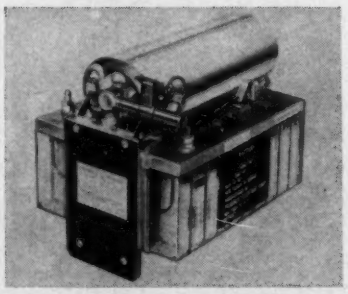


attached to leading edge. May be hand-wired to provide prototypes for final printed circuit plug-in components, or as base for lab test circuits.—*Vector Electronics Co.*, 1100 *Flower St., Glendale* 1, *Calif.*

CIRCLE 191 ON READER-SERVICE CARD

ONE-SHOT PRIMARY BATTERY

New automatically activated silver-zinc battery consists of 18 cells of 20 ampere-hour capacity plus auto-



matic activation mechanism, for standby power in missile and other military systems. Standby life is 3 years, can be readied in 2 seconds.—*Yardney Electric Corp.*, 40-50 *Leonard St., New York, N. Y.*

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Probescope Sonic and Ultrasonic analyzers all have automatic optimum resolution circuitry. Guesswork has been taken out of spectrum analysis. One control sets the proper bandwidth and sweepwidth to give the best possible resolution... other features include... 60 db dynamic range... linear and log amplitude scales... internal calibration markers.

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Resolution	14 cps

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Frequency Range	13.5 cps to 110 kc
Sweep Width	200 cps to 20 kc
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Resolution	27 cps

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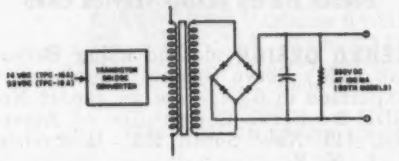
Airborne Transistorized Power Supplies models TPC-18A and 19A are designed for plug-in replacement of D-10A Dynamotors as power sup-



ply for aircraft communications and navigation receivers. Transistor multi-vibrator circuit gives good regulation, high efficiency and overload protection.—*Southwestern Industrial Electronics Co., P. O. Box* 22187, *Houston* 27, *Tex.*

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SIZE 9 AC POTENTIOMETER

New Series 4 Vernistat precision ac potentiometer has front end machined down to fit BuOrd Size 9

mounting requirements permitting retrofit applications of the Series 4 Vernistat in systems designed for conventional size 9 pots.—*Vernistat Div., Perkin-Elmer Corp., Norwalk, Conn.*

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Complete selection of glass rods for electron gun fabrication with accelerated delivery time is feature

of new Mansol rods delivered in exact lengths specified by tube manufacturer.—*Mansol Ceramics Co.,* 140 *Little St., Belleville, N. J.*

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H-V REGULATOR PENTODES

New 3-tube line of miniature high-voltage pentodes for use with Victoreen's Corotron regulator tubes are designated types 7234, 6842 and 7683.

They cover voltage ranges from 300 to 10,000 v and have transconductances as high as 5000 μmhos.—Full data on request.—*Appl. Eng. Dept., The Victoreen Inst. Co.,* 5806 *Hough Ave., Cleveland* 3, *Ohio.*

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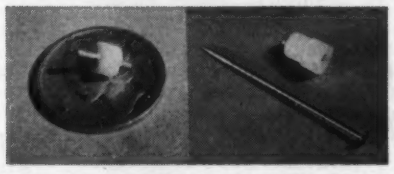
TINY JACK AND PLUG

Type PR-11 subminiature probe for in-line use (left) has 0.040" diameter probe on each end of straight Teflon



Body. Mates with Type SKT-30 jack (right) which also serves as handy external test point designed for "Press-Fit" mounting.—*Sealectro Corp.,* 139 *Hoyt St., Mamaroneck, N. Y.*

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RIBBON HOOK-UP WIRE

Hook-up wire harness in the form of factory-fabricated flat ribbon are available in any combination of color-coded vinyl insulated wires, from

20 to 30 conductors, depending on the size of the conductors.—*Times Wire & Cable Co., Inc.,* 358 *Hall Ave., Wallingford, Conn.*

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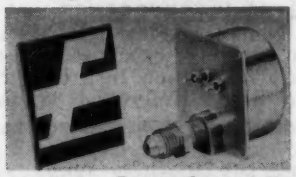

measurements. Less than 1% error under 15 G at 2000 cps or 25G shock. —*Fairchild Controls Corp., Components Div.,* 225 *Park Ave., Hicksville, L. I., N. Y.*

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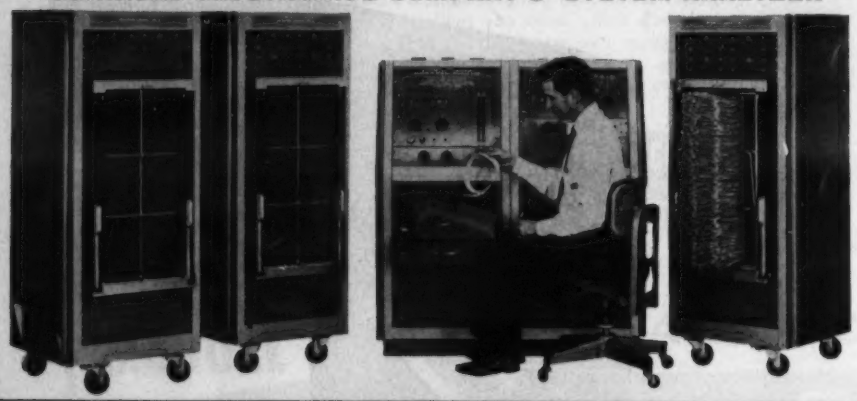

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MSD new literature

GYRO TECHNICAL DATA on Type Q2315 Free Gyro, B2115 Vertical Gyro, and A2215 Directional Gyros are contained in three 2-page data sheets.—Kearfott Co., Inc., Little Falls, N. J.

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CATHODE RAY TUBE data chart for Military and Industrial applications is given in 6-page folder.—Thomas Electronics, Inc., 118 Ninth St., Passaic, N. J.

CIRCLE 202 ON READER-SERVICE CARD

SHOP DATA collection and processing of time and stock records by automatic system is described in new 20-page Collectadata technical manual.—Friden, Inc., San Leandro, Calif.

CIRCLE 203 ON READER-SERVICE CARD

MINI RELAY with 5 mw sensitivity is described in new 2-page technical bulletin BR-593.—Babcock Relays, Inc., 1640 Monrovia Ave., Costa Mesa, Calif.

CIRCLE 204 ON READER-SERVICE CARD

SELF-GENERATING ACCELEROMETERS with high temperature and high output characteristics are described in new 2-page technical bulletin 9503.—Clevite Electronic Components Div., 3405 Perkins Ave., Cleveland 14, Ohio.

CIRCLE 205 ON READER-SERVICE CARD

VARIABLE INDUCTORS, miniature, have physical and electrical parameters described in new 2-page data sheet.—Essex Electronics, Div. of Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J.

CIRCLE 206 ON READER-SERVICE CARD

ROTARY SOLENOIDS in "F" size (300 in-lb°) and "C" size (70 in-lb°) are described in separate 2-page specification sheets.—Pacsol Div., Illinois Tool Works, 3155 El Segundo Blvd., Hawthorne, Calif.

CIRCLE 207 ON READER-SERVICE CARD

HF RADIO INTERFERENCE and field intensity meter Model NM-20B is described in 4-page brochure.—Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

CIRCLE 208 ON READER-SERVICE CARD

ACOUSTIC NOISE generator for component testing with 166 db random noise sound intensity output is described in new 4-page bulletin.—Avco Research & Adv. Development Div., 201 Lowell St., Wilmington, Mass.

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← CIRCLE 71 ON READER-SERVICE CARD

MAGNETOHYDRODYNAMIC POWER generation principles and techniques are discussed in new 4-page bulletin.—Product Information, Missile and Space Vehicle Dept., General Electric Co., Philadelphia 4, Pa.

CIRCLE 210 ON READER-SERVICE CARD

SERVO DESIGN method using Servolab (TM) Servo System Simulator is explained in 6-page design report No. SDH-2.—Servo Corporation of America, 111 New South Rd., Hicksville, L. I., N. Y.

CIRCLE 211 ON READER-SERVICE CARD

MICROFILM applications in filing, retrieval, copying and communication in business and industrial management are described in new 6-page booklet.—Minnesota Mining & Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

CIRCLE 212 ON READER-SERVICE CARD

LEAK DETECTOR conversion factors, formulae and performance charts for users of mass spectrometer-type leak detectors are contained in 4-page bulletin 1857.—Consolidated Electrodynamics Corp., Subsidiary of Bell & Howell Co., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 213 ON READER-SERVICE CARD

JET TRANSPORT pilot training utilizing new Link Cockpit Simulators is described in new 12-page brochure.—Link Div., General Precision, Inc., Binghamton, N. Y.

CIRCLE 214 ON READER-SERVICE CARD

PLANETARY Physical Data, also equations for missile and satellite trajectories are contained in handy 26-page booklet.—Missile and Space Vehicle Dept., General Electric Co., 3193 Chestnut St., Philadelphia 4, Pa.

CIRCLE 215 ON READER-SERVICE CARD

GROUND SUPPORT Checkout systems from production line to pre-flight are described in 4-page brochure.—CSE Systems Div., Adler Electronics, Inc., One LeFevre Lane, New Rochelle, N. Y.

CIRCLE 216 ON READER-SERVICE CARD

MINIATURE CAPACITORS using etched aluminum foil are described in 6-page Bulletin 81558.—International Electronic Industries, Inc., Box R26, Nashville, Tenn.

CIRCLE 217 ON READER-SERVICE CARD

PNP SILICON ALLOY transistors types 2N1440, 2N1441, and 2N1442 meeting MIL-T-19500A for low level, small signal and medium power use are described in separate 4-page technical bulletins.—National Semiconductor Corp., Danbury, Conn.

CIRCLE 218 ON READER-SERVICE CARD

CERAMIC CAPACITORS from subminiature and printed circuit types to high-voltage, high-capacity industrial types are described with design characteristics in 30-page catalog.—HiQ Division, Aerovox Corp., Myrtle Beach, So. Carolina.

CIRCLE 219 ON READER-SERVICE CARD

PIEZO-CERAMIC elements of ultra-stable ferroceramic materials are described in new 4-page "Michelite" bulletin.—Universal Dynamics Corp., 130 Los Aguajes Ave., Santa Barbara, Calif.

CIRCLE 220 ON READER-SERVICE CARD

WIREWOUND Variable Resistors meeting MIL-R-19A Style RA20 are described in 4-page technical bulletin A-36.—CTS of Asheville, Inc., Skyland, N. Carolina.

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TEN-TURN POT for servo mounting, ⅞" dia., is completely described in new 4-page data sheet No. 60150.—Helipot Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 222 ON READER-SERVICE CARD

BINARY-to-Decimal converter for Nixie Tube display is described in new 2-page technical bulletin No. 260.—Hermes Eelectronics Co., 75 Cambridge Parkway, Cambridge 42, Mass.

CIRCLE 223 ON READER-SERVICE CARD

MINIATURE SILICON CONTROLLED rectifiers (1 amp, 30 to 200 v) are described in new 4-page technical bulletin.—Solid State Products, Inc., One Pingree St., Salem, Mass.

CIRCLE 224 ON READER-SERVICE CARD

APPLYING THERMAL CHARACTERISTICS of silicon voltage reference diodes is subject of 4-page Semiconductor Application Bulletin Vol. 1 No. 8 for design engineers.—Hoffman Electronics Corp., 1001 Arden Dr., El Monte, Calif.

CIRCLE 225 ON READER-SERVICE CARD

STATIC INVERTER-CONVERTER (DC to DC/AC) system with exotic solid-to-liquid coolant is described in 2-page data sheet.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

CIRCLE 226 ON READER-SERVICE CARD

MISSILE and AIRCRAFT Ground Power equipment components are described in new 12-page bulletin GEA-6973.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 227 ON READER-SERVICE CARD

HYDRAULIC PUMPS using fixed angle variable delivery principle for missiles and aircraft are described with performance curves in new six-page brochure.—Vickers, Inc., Detroit 32, Mich.

CIRCLE 228 ON READER-SERVICE CARD

LINEAR ACCELEROMETERS for flight test instrumentation of TITAN and MINUTEMAN are described in new bulletin LA-500.—Minneapolis Honeywell, Boston Div., Dept 55, 40 Life St., Boston 35, Mass.

CIRCLE 229 ON READER-SERVICE CARD

POWER SUPPLY Selection chart provides quick guide to characteristics of 75 dc power supplies in new 16-page catalog.—Dressen-Barnes Corp., 250 No. Vinedo Ave., Pasedena, Calif.

CIRCLE 230 ON READER-SERVICE CARD

EQUIPMENT CASES of ALPLY laminated construction meeting all applicable MIL-Specs are described in new 8-page catalog H.—Zero Mfg. Co., Burbank, Calif.

CIRCLE 231 ON READER-SERVICE CARD

CONTROL PACKAGING Capability in electronic control field is illustrated by specific military projects in new 6-page facilities brochure.—Breeze Corporations, Inc., 700 Liberty Ave., Union, N. J.

CIRCLE 232 ON READER-SERVICE CARD

METAL CASES for housing electronic components are specified in new 4-page data sheet on aluminum, copper, steel, brass and mu metal round drawn cases.—Olympic Products Co., Inc., Alpha, N. J.

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REUSABLE TRANSIT/INSTRUMENT Cases for military equipment furnishing high environmental protection made from Zero Bond Alply are described in 8-page catalog H.—White Div., Zero Mfg. Co., Palmer, Mass.

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MISSILE V-band couplings, flanges and joints to connect and seal all types of tubing, piping, ducts and containers are listed in new 40-page catalog No. 800.—Marman Div., Aeroquip Corp., 11214 Exposition Blvd., Los Angeles 64, Calif.

CIRCLE 235 ON READER-SERVICE CARD

COAX CONNECTORS in snap-locking micro-miniature models are described and specified in new 6-page catalog.—EPL Technical Information Service, Electro-Physics Laboratories, 2065 Huntington Drive, San Marino, Calif.

CIRCLE 236 ON READER-SERVICE CARD

PRINTED CIRCUIT information needed when ordering is listed in new 4-page bulletin No. 1159.—Whitney Blake Co., New Haven 14, Conn.

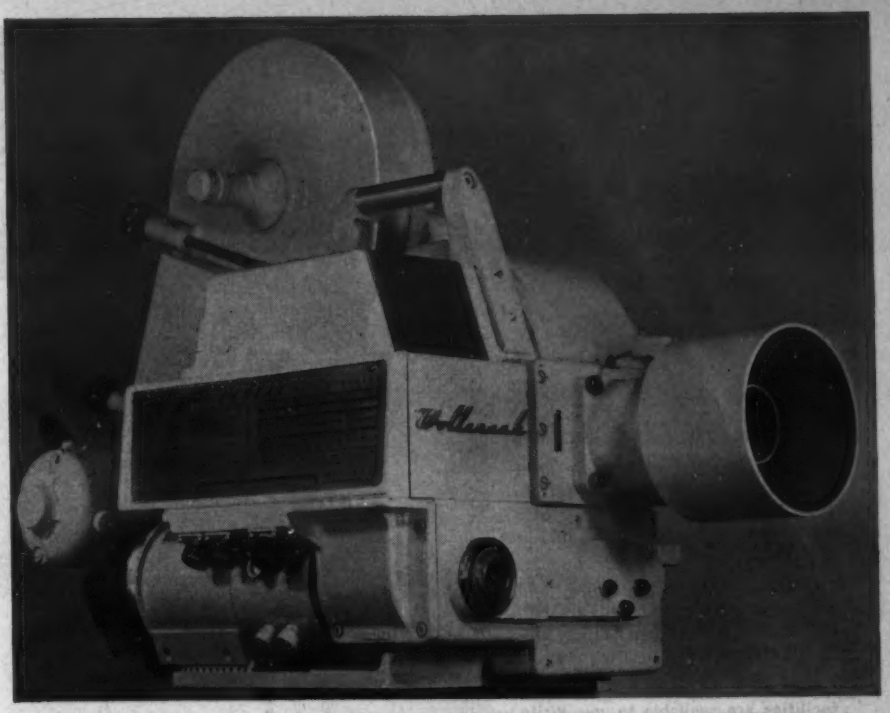
CIRCLE 237 ON READER-SERVICE CARD

MINIATURIZED PRINTED CIRCUITS is title of 2-page technical bulletin P-5a which explains process of producing landless plated-thru holes to improve component density.—Photocircuits Corporation, 31 Sea Cliff Ave., Glen Cove, N. Y.

CIRCLE 238 ON READER-SERVICE CARD

PRESSURE transducers giving potentiometer outputs for absolute or gage values in the 250 or 10,000 psi ranges are described in new 2-page bulletin TPH-175.—Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, L. I., N. Y.

CIRCLE 239 ON READER-SERVICE CARD



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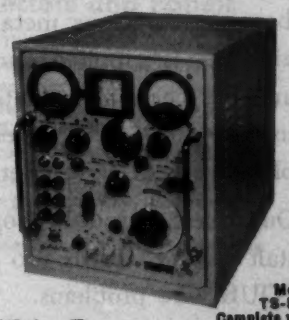

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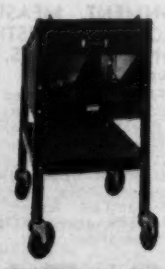

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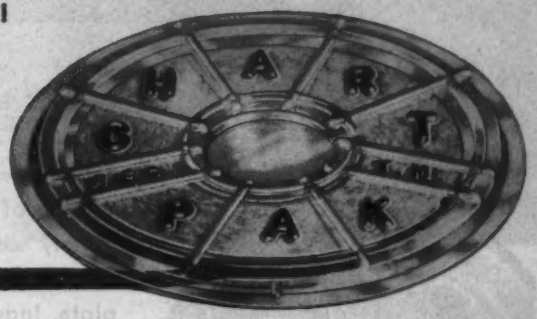

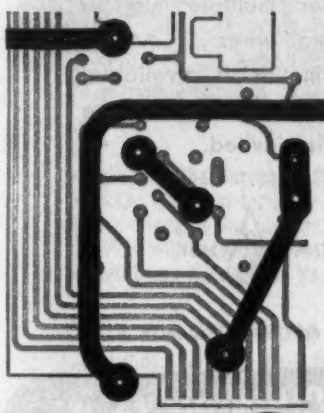

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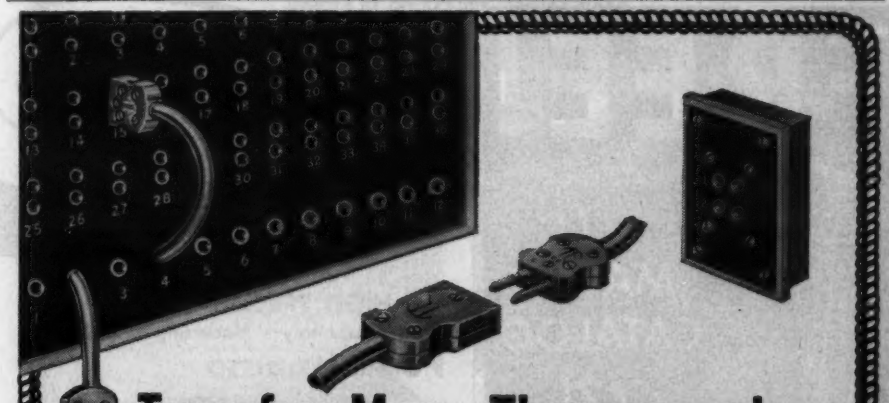

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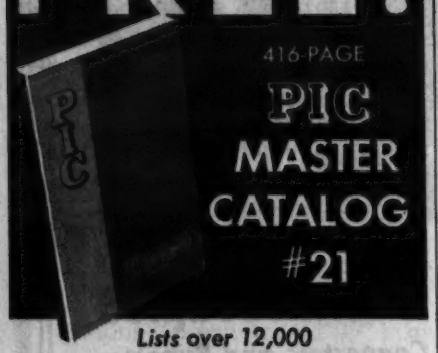

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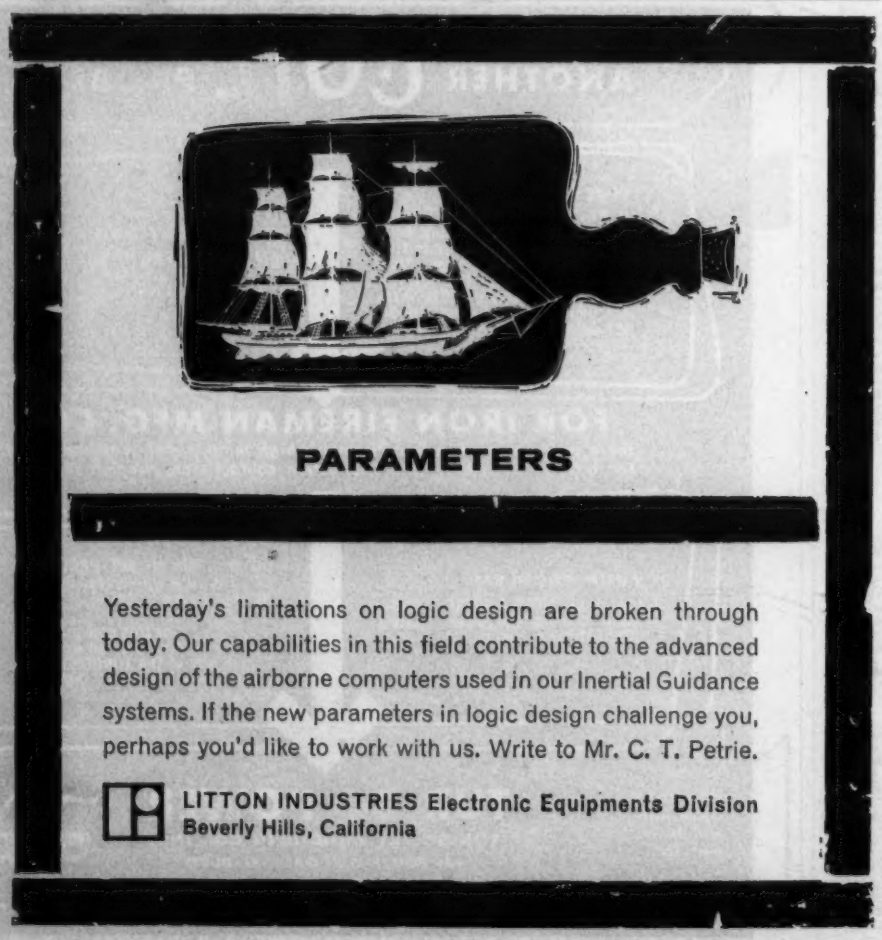

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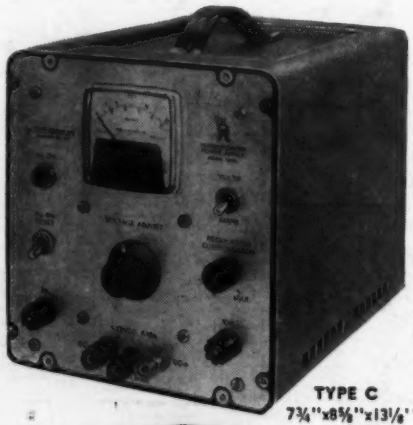

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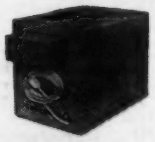

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June 16-18—Fifth Annual Symposium and Exhibit of the American Scientific Glassblowers Society, Penn-Sheraton Hotel, Pittsburgh, Pa. Twenty papers will be presented in five sessions by nationally recognized authorities in the glass-working field. Write to W. E. Barr, Gulf Research & Development Co., P. O. Box 2038, Pittsburgh 20, Pa.

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June 27-29—4th National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C., PGME-IRE. Write Chas. De Vore, 3224 16th St., N. W., Washington 10, D. C.

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